MET 12

PRECISION

HOLT
INSTRUMENT
LABORATORIES
OCONTO WISCONSIN

MEASUREMENT

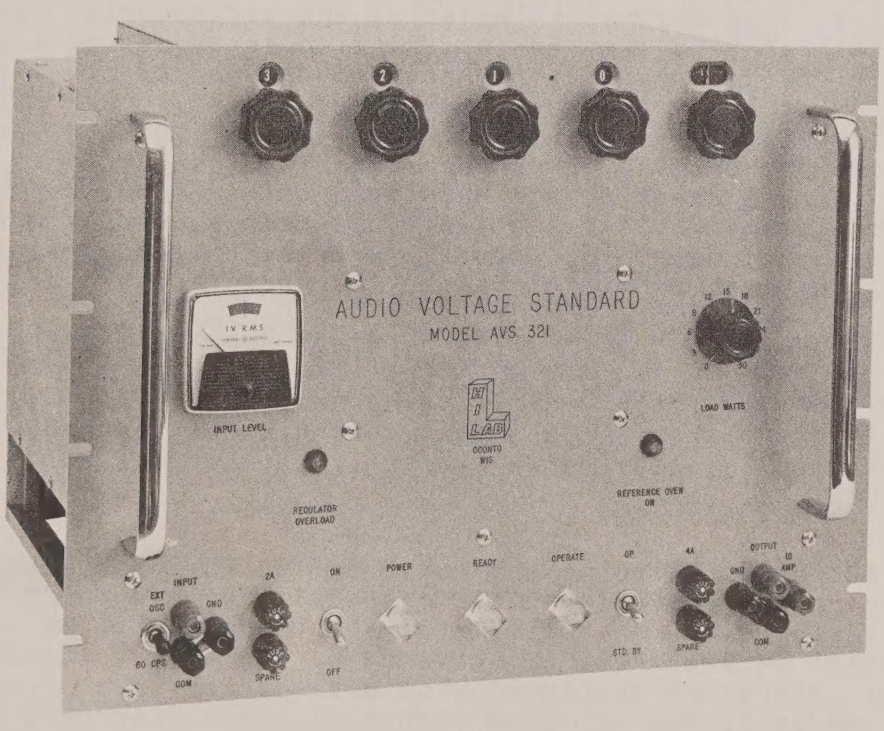
OPERATING & SERVICING MANUAL

FOR

AUDIO VOLTAGE

STANDARD

MODEL AVS-321



1438

THIS MANUAL TO ACCOMPANY

SERIAL NO. 1436

HOLT INSTRUMENT LABORATORIES

OCONTO, WISCONSIN

MARCH 1963 EDITION

CLAIM FOR DAMAGE IN SHIPMENT:

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local Representative immediately. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY:

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipments of Holt Instrument Laboratory equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

TECHNICAL SPECIFICATIONS

REGULATION RANGE:	1 volt to 299.99 volts RMS 35cps to 10KC. 300 volts to 1000 volts RMS 35cps to 2KC.
REGULATION ACCURACY:	Regulated voltage is equal to the dial setting ± (0.1% + 2mv.) from 1 volt to 299.99 volts. From 300 volts to 1000 volts accuracy is ± 0.25%.
STABILITY:	The output will remain within the above absolute voltage tolerances for thirty days under laboratory conditions. Long-term drift may be corrected by a simple adjustment against a primary lab. standard.
OUTPUT WAVEFORM:	Sinusoidal.
DISTORTION:	0.15% 1 volt to 299.99 volts + input distortion. 0.5% 300 volts to 1000 volts. Highest accuracy will be obtained when driven from an oscillator having less than 0.1% distortion.
INTERNAL OSCILLATOR:	60 cps Harmonic distortion less than 0.1%
REGULATION RESPONSE:	A maximum time constant of 200 milli-sec. and a damping factor of 0.6.
OUTPUT CURRENT:	Unity power factor 10 Amps. @ 1 volt 3 Amps. @ 1.1 volt to 9.99 volts 300 Ma. @ 10 volts to 99.99 volts 100 Ma. @ 100 volts to 299.99 volts 30 Ma. @ 300 volts to 1000 volts
REQUIRED DRIVING VOLTAGE:	Approximately 1 volt RMS 35cps to 10KC. 600 Ω input impedance
POWER SOURCE:	105 volts to 125 volts 60 cps. 550 watts.
MECHANICAL:	19 inch rack mounting. 14 inches high. 15 inches deep.

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I-1 GENERAL DESCRIPTION:

The model AVS-321 is an extremely stable electro-mechanical audio frequency voltage regulator. It includes a high quality audio power amplifier with a special multi-tap output transformer. It should be driven by a low distortion amplitude stable audio oscillator. Together these units form a precision source of sine wave audio frequency voltage. The unit will regulate voltages from 1 volt to 1,000 volts at frequencies from 35 cycles to 10,000 cycles.

The instrument may be used as a source for calibrating other A.C. instruments. In conjunction with an accurate A.C. voltmeter it may be used for testing components such as transformers, condensers and inductors. This method of component testing is much faster than bridge testing and tests may be made over a broad range of frequencies. The instrument also may be used as a source for frequency response testing of amplifiers and audio frequency filters, making faster, more accurate readings possible.

I-2 POWER CABLE:

Supplied with the instrument is a three conductor power cord terminated in an NEMA recommended, polarized, three-prong male connector. The large rectangular pin should connect to the common side of the A.C. power line; the small rectangular pin to the hot side of the line. The chassis of the instrument is connected to the large round pin of the connector. It is important that this be connected to a ground connection which is returned to earth with a minimum of noise. Large amounts of noise or 60 cycle voltage on the instrument chassis will affect the accuracy of regulation. See

the operating instructions for procedures to test the amount of noise present in the regulating loop.

1-3 POWER LINE VOLTAGE:

The instrument is designed for operation on power line voltage of 115 volts plus or minus 10%. If line voltage is consistently high or low the power transformers are provided with taps for 105 and 125 volts. In using these taps care should be taken to prevent prolonged operation on high or low line voltages.

1-4 OPERATING TEMPERATURES:

The AVS-321 is equipped with a fan to circulate air to prevent overheating. The unit will operate without difficulty at normal ambients. However, if it is enclosed in a cabinet or rack it should be provided with enough air circulation to keep the internal temperatures below 50°C. The voltage reference zener is regulated in an oven at 55°C. Any condition that will cause the oven to lose control may alter the output voltage of the unit.

2-1 TERMINALS AND CONTROLS:

Power Switch: This toggle switch connects power to the primary of the filament transformer and to the heater of a thermal time delay relay which energizes the plate power transformer after 30 seconds. When the time delay actuates, the ready light will turn on.

Stand-by Switch: The Stand-by switch connects power to the servo motor and chopper, and connects the input to the power amplifier. The Operate light will turn on when this switch is placed in the operate position.

Fuses: The 2 amp fuse on the left side of the panel is in the primary circuit of the filament transformer. The 4 amp fuse on the right side of the panel is in the plate and servo motor supply circuits.

Decade Output Control: The five controls at the top of the panel control the output voltage by selecting the proper taps on the output transformer and the precision resistors of the regulator input attenuator.

Load Control: The load watts switch controls a resistive load on the power amplifier.

External Oscillators - 60 cycle switch: This switch connects the input of the unit to the front panel terminals or to the internal 60 cycle wien bridge oscillator.

Input Terminals: The three terminals on the lower left side of the instrument are connected to the input of the power amplifier via the regulating servo potentiometer. The top red terminal is the signal

input terminal and the black terminal directly below it is signal common. The black terminal to right of the signal and signal common terminals is the chassis ground terminal.

Output Terminals: The four terminals on the lower right side of the front panel are the output voltage connections. Here, the left terminal is chassis ground. The top red terminal is the output voltage with respect to the black lower common terminal. This output common terminal is the common end of the output transformer and is not connected internally to the common terminal of the input terminals. The output red terminal and the common black terminal are used for all output voltages one volt and above. The red terminal on the right labeled 10 AMP must be used for obtaining up to 10 amps of current at one volt when the output is set to one volt. When the instrument leaves the factory, it has a connecting link between the common and chassis ground on both the input and output terminals. See section GROUNDING AND INTERFERENCE for rack mounting and system grounding techniques.

2-2 OPERATION:

With unit in stand-by connect a high quality, low distortion oscillator to the AVS-321 as shown in Figure 2-2.1. Turn on the oscillator and set its output voltage to approximately 1.0 volt and the desired frequency. After allowing ample warm-up time, set the control switches to the desired output voltage. Set the load watts switch to the approximate power required by the load under test. This setting is not critical. An accuracy of plus or minus 3 watts will not affect the output voltage accuracy.

When the ready light turns on, the unit may be switched to operate. The unit should be allowed to warm-up at least 20 minutes. For maximum accuracy allow 1 hour warm-up. The output of the low distortion oscillator may vary from .75 to 1.25 volts as indicated by the green

region on the input level meter. The regulator will completely correct for variations within these limits. If the oscillator output varies too much or too fast, the regulator overload light will glow in the panel. If regulator overload light continues to glow, check for the reason. This indication usually means the output is not within specified limits.

CHANGING VOLTAGE:

To change output voltage it is generally good practice to place the AVS-321 in "Stand-by" before making the voltage change. This may prevent an accidental high voltage being applied to any connected equipment. If currents of one ampere or more are being drawn in the range below 10 volts then it is advisable to place the AVS-321 in "Stand-by" to prevent arcing of switch contacts and heavy transients in the unit.

At other times it may be advantageous to be able to adjust the output voltage with the test setup in operation. This may be accomplished without endangering the AVS-321 if the dials are rotated from step to step rapidly without stopping in between dial positions.

NOTE: The output voltage is removed from the terminals when the unit is in stand-by.

CHANGING FREQUENCY:

The output frequency may be changed by changing the oscillator frequency. No readjustment of the AVS-321 is necessary. Place the AVS-321 in Stand-by when changing oscillator range.

REGULATION CHARACTERISTICS:

The AVS-321 is a power amplifier with a servo type voltage regulator in the feed back loop. Necessarily this regulator has a finite time constant and resolution. The time constant of the AVS-321 is less than 0.2 sec. The system has a damping factor of 0.6. Servo dead space is approximately 0.01%. Due to these factors small short-term

variations in the input signal will not be corrected by the regulator.

In most calibration work, where thermo-couple or moving coil instruments are being calibrated, the time constant and damping of the meter being read are long enough to filter out most of these short-term transients.

When calibrating the new expanded scale and digital instruments which have extremely high resolution and short time constants any small variation in the oscillator output will be seen as a fast fluctuation in the reading or a cyclic variation in the least signigicant digit of the digital meter.

2-3 AUDIO OSCILLATOR SPECIFICATIONS:

The general requirements of the oscillator used to drive the AVS-321 are specified elsewhere in this manual but will be repeated here for convenience. To cover the operating range of the AVS-321, the oscillator must provide one volt RMS into 600 ohms from 35 cps to 10 KC. Long term amplitude stability must be within $\pm$ 25% for the regulation range of the AVS-321. Long term as used here is 1 second or longer. Total distortion of the signal should be .1% or less. Frequency tolerance of the oscillator signal is not critical as long as it remains within the specified range. The instrument or device under calibration or test will usually dictate the frequency tolerance.

Due to the regulation characteristics of the AVS-321 additional short term amplitude requirements may have to be met when calibrating expanded scale and digital instruments which have extremely high resolution and short time constants. Recognizing that amplitude variations and jitter, that occur at a rate faster then .1%/second appear at the output terminals of the AVS-321, it is recommended that the oscillator used have excellent short term amplitude stability.

To define short term amplitude stability we must know the needs of the voltmeters being calibrated. Most of these high resolution

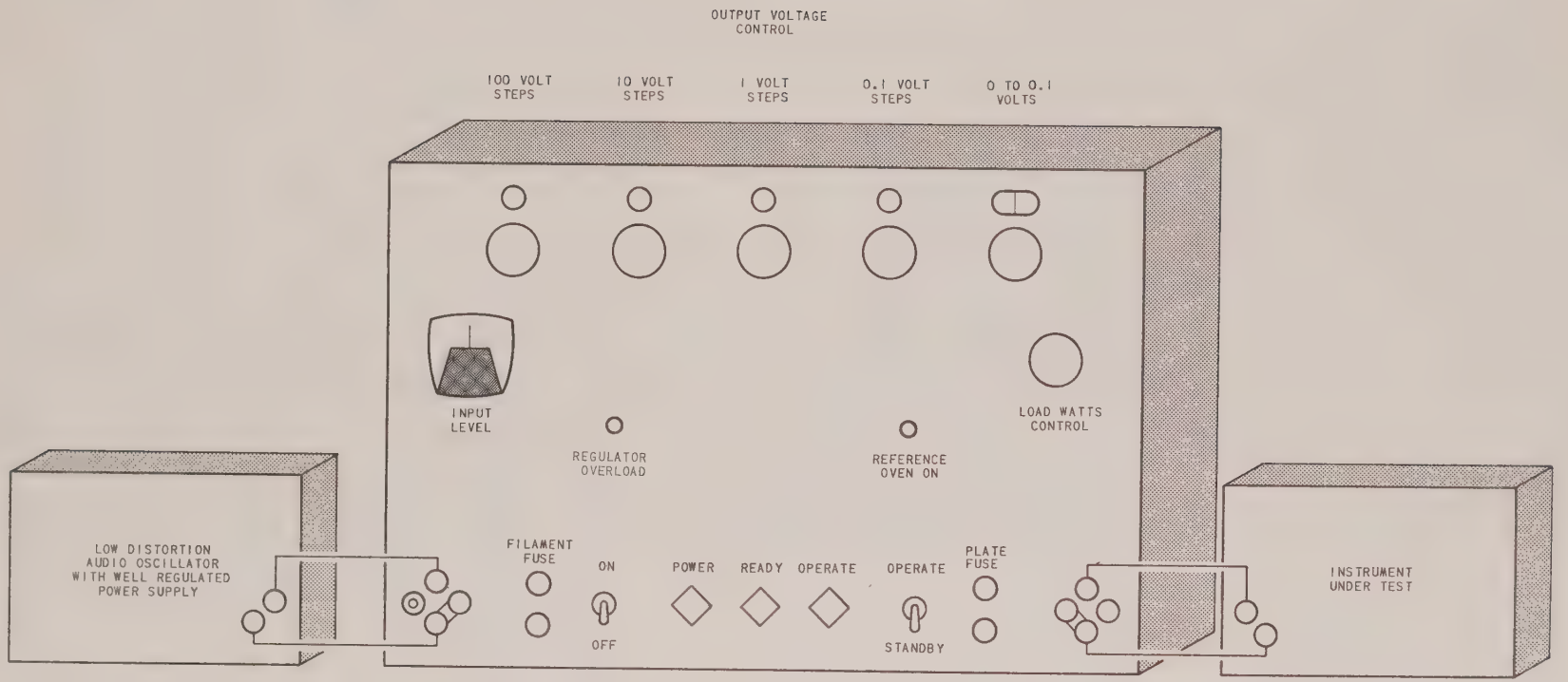

OUTPUT VOLTAGE CONTROL
100 VOLT STEPS
10 VOLT STEPS
1 VOLT STEPS
0.1 VOLT STEPS
0 TO 0.1 VOLTS
INPUT LEVEL
REGULATOR OVERLOAD
REFERENCE OVEN ON
LOAD WATTS CONTROL
LOW DISTORTION AUDIO OSCILLATOR WITH WELL REGULATED POWER SUPPLY
FILAMENT FUSE
ON
OFF
POWER
READY
OPERATE
OPERATE
STANDBY
PLATE FUSE
INSTRUMENT UNDER TEST

Figure 2-2.1

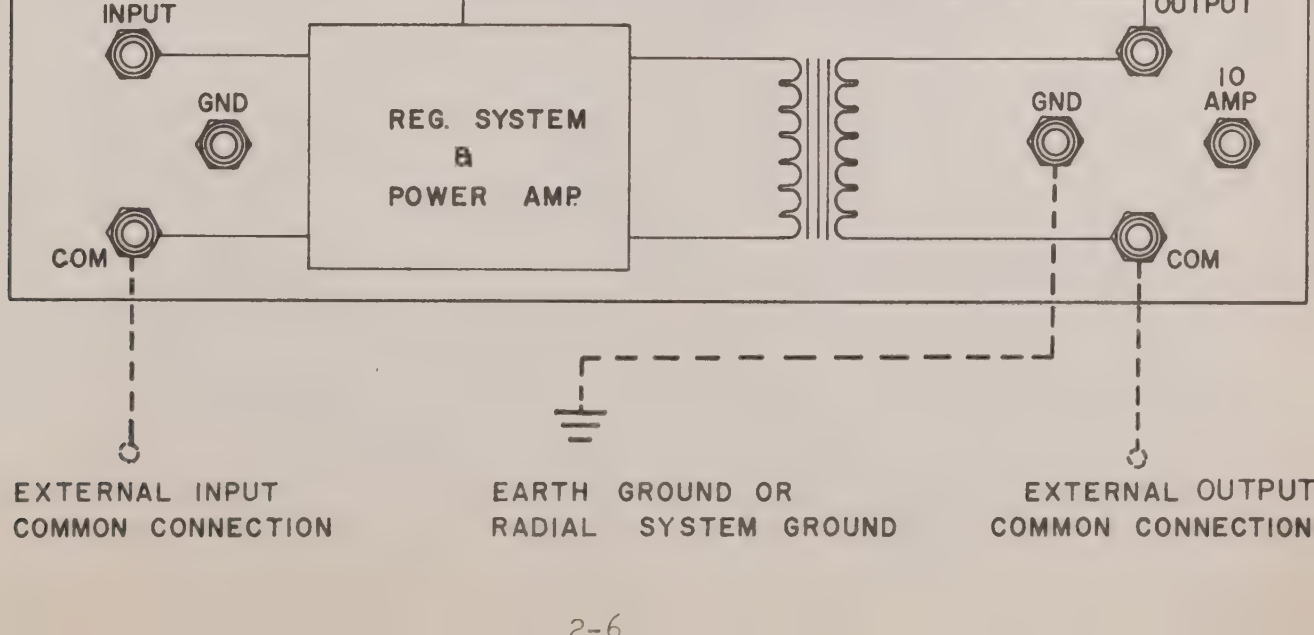
high speed voltmeters are of the rectifier type. The Fourier analysis of a full wave rectified wave form indicates the presence of at least 120% peak to peak second harmonic ripple. To reduce this ripple to .012% so that it will have negligible effect on the high resolution measurement an attenuation of at least 80 db is required. If a maximum filter slope of 60 db/decade is assumed the smoothing filter must have a cutoff frequency no higher than 1/20th of the lowest frequency to be measured. For example, a meter designed to measure frequencies down to 30 cycles would have a cutoff of 1.5 cycles and a time constant of no less than 110 milliseconds. Therefore if the output of the oscillator is stable enough that its output averaged over 110 milliseconds is varying at a rate of less than .1%/second the voltmeter will filter out all variations faster than this and the AVS-321 servo will regulate out the slower variations.

2-4 GROUNDING AND INTERFERENCE:

To test the instrument for the presence of excessive 60 cycle hum in the ground circuits connect an oscilloscope to test points TP 101 and TP 102 on the servo amplifier board. TP 102 is the grounded terminal. The peak to peak voltage at this point should not exceed 50 milli-volts when the servo is at null with the instrument in operation at a frequency of 1,000 cycles. With the scope sweep at 2 milli-seconds per Cm. and sync on the line, the waveform should be a distorted 60 cycle voltage. Forcing the servo gear to one side or the other with the finger will make this error signal increase and shift phase by plus or minus 90 degrees. A change of 300 milli-volts in the peak to peak value of this waveform from its magnitude at null is equal to a change of approximately 0.1% in the regulated A.C at the output of the AVS-321.

When the sweep speed is slowed to 0.2 seconds/cm, the waveform envelope will show the changes in this servo null signal caused by transients in the oscillator and AVS-321. The peak to peak magnitude of the envelope should not change by more than 300 millivolts on these transients and should recover to the null value within 0.6 seconds. Continued transients with no solid null usually indicated instability in the driving oscillator amplitude or the AVS-321 power supply. For more detailed analysis of these waveforms, see Section 4-2.

The instrument is wired such that the output, regulating system and chassis grounds are connected only by the front panel grounding links. The simplified diagram below shows the internal connections and why the links are necessary between common and chassis ground. If either of the links are removed it is necessary to connect the two common terminals externally to provide a signal return path for the sensing voltage.



This terminal arrangement in the AVS-321 allows grounding system versatility in a calibration or measurement system. For example, when the instrument is rack mounted both input and output signal common can be isolated from the chassis and rack panel ground. The two common terminals can be connected radially to the system signal ground. Or, under high current loads, the input common terminal may be connected directly to the load to remove the voltage drop in the current carrying output common lead. Also, the chassis ground can be connected to a remote or radial ground.

The foregoing diagram and explanation indicates the terminal connections of the AVS-321. With this information and choice of connections, the user is cautioned to be aware of the possibility of introducing error in calibration due to hum, noise and magnetic pick-up in signal common and chassis ground external leads. The user is also cautioned against elevating the common terminals with any voltage with respect to the chassis ground terminal.

SETTING THE SERVO GAIN:

The gain of the servo amplifier will affect the servo dead space and in some cases the overall short-term stability of the unit. This adjustment is accurately set at the factory as part of the calibration procedure. However, occasionally this may demand resetting, due to tube aging.

To do so, connect an oscilloscope to TP 101 and observe the error signal, unit in Operate, starting with R-118 (Servo gain adjustment) fully counter-clockwise. The servo motor is fully disabled and the error signal will be large, dependent on the difference between the output of the AC-DC converter and the reference voltage. Adjust R-118 by turning it clockwise until the servo motor seeks a null position. The error signal at this point should reduce in amplitude to nearly a straight line.

Occasionally, it may become larger as the servo attempts to stabilize the output signal amplitude. Continue to turn R-118 until a point is reached where the error signal amplitude becomes large again . At this point the servo gain is excessive and the servo gear will jitter rapidly. Turn the servo gain adjustment R-118 back until the jitter stops.

To insure that this control is properly set, place a finger against the servo gear, (below the unit on the left hand side.) The gear should be stiff and require some pressure to move it off this null point. It should not be jittering. The optimum setting is achieved when maximum stiffness is attained without allowing the servo to jitter.

3-1 GENERAL:

The AVS-321 consists of the following basic assemblies:

a. The precision VOLTAGE CONTROL permits continuous selection of output potentials from 1 to 1000 volts. It also attenuates the output voltage to the one volt AC converter input.

b. The AC TO DC CONVERTER rectifies this signal and amplifies it with a highly stable conversion gain.

c. The AUDIO FILTER filters the half wave rectified output of the Converter to a smooth DC signal having less than 0.1% peak to peak ripple.

d. The SERVO AMPLIFIER compares this DC signal to a highly stable DC reference and amplifies the difference or error to provide driving power for the servo motor.

e. The SERVO MOTOR AND POTENTIOMETER act as an automatic gain control for the input to the power amplifier, adjusting the signal level to the power amplifier to maintain its output at exactly the selected level.

f. The POWER AMPLIFIER produces full output power continuously with less than 0.15% harmonic distortion. The frequency response is plus or minus one db from 35 cycles to 10,000 cycles. The output of the power amplifier is monitored and controlled by the regulator system parts (a) through (e) above.

g. The POWER SUPPLY furnishes all the AC and DC power to operate the instrument.

3-2 VOLTAGE CONTROL:

The AVS-321 provides a range of output voltages from 1 to 1,000 volts at the input frequency. The selected output is continuously

variable with the four decade switches and a variable resistor. The decade switches select the proper output transformer tap or taps to give the desired voltage. The block diagram illustrates how various taps are connected and added to achieve all possible potentials. The decade switches, in addition to selecting the proper output voltage, selects the attenuator resistor or resistors permitting a very accurate division of the output voltage to the 1 volt level fed to the AC Converter.

The attenuator is a constant current attenuator, made up of special, precision, wire wound resistors. These resistors have a very small time constant with a correspondingly good frequency response. The resistors are bridged at the time of assembly to insure accuracy of three-hundredths of a percent or better.

The attenuator is mechanically arranged for a minimum of stray capacitance both from the resistor to ground and shunt capacity across the resistors. The resistors are rigidly mounted so that capacitive effects are stable and can be compensated for at the time of calibration. Subsequently, it is very important that the physical position of the attenuator components be maintained between high frequency calibrations. Because of the lower impedances used at the lower voltages, they are somewhat less critical with respect to stray capacitance.

The output of the attenuator is 1 volt RMS into a 300 ohm load. This one volt is maintained, **regardless of attenuator dial setting,** by selecting the proper attenuator resistors. This selection is done automatically by extra switch sections as the desired output voltage is selected. At one volt selected output, there are no attenuator resistors in the circuit, but rather the one volt is fed directly from the output terminals to the 300 ohm load in the AC Converter. At voltages above one volt, the proper fixed attenuation is provided.

A trim resistor is provided on the AC to DC Converter in series with the 300 ohm load to set the exact attenuator ratio. Caution is urged that this adjustment be made only at calibration where the instrument's output can be checked against primary standards. (See calibration procedure, Section IV, and data sheets enclosed with each instrument.)

The 10,000 ohm grid input resistor in the AC-DC Converter is shunted with a high frequency compensating network. These components provide the necessary frequency compensation. Their sizes are peculiar to each individual unit and are factory set.

3-3 THE AC TO DC CONVERTER:

The AC to DC Converter is a high gain broad band amplifier with two silicon diodes in a feedback loop which reduces the closed loop gain of the amplifier to 28 db. The diodes are arranged so that the positive half cycle of the feedback current flows through a precision resistor and the output of the converter is taken across this resistor. The output is therefore a half wave rectified voltage which is proportional to the half cycle of the feedback current. Due to the high gain of the amplifier, the summing junction at the input of the amplifier is held very close to zero potential and since there is no current flowing in the grid circuit of the input tube, the input and feedback currents are equal and the output voltage of the AC to DC converter is a function only of the input voltage and the values of the precision resistors, located in the feedback loop. Referring to Figure 3-3-1 the circuit operates in accordance with the following equations.

Since the input grid draws no current

eq. 3.3.1 $I_2 = 0$ Therefore $I_1 = I_3$

eq. 3.3.2 $$\frac{E_{In} - e}{R_1} = \frac{e - E_2}{R_2}$$

THEORY OF OPERATION:

Solving 3.3.2 for E_2

eq. 3.3.3 $$E_2 = -\frac{R_2}{R_1} E_{In} + e\left(1 + \frac{R_2}{R_1}\right)$$

Let K equal amplifier gain from point A to B.

eq. 3.3.4 $$e = -\frac{E_2}{K}$$ Where the minus denotes phase inversion in the amplifier.

And since $R_1 = R_2$

eq. 3.3.5 $$E_2 = -E_{In} - \frac{2E_2}{K}$$

Or

eq. 3.3.6 $$E_2 = -E_{In}\left[\frac{1}{1 + \frac{2}{K}}\right]$$

During the positive half cycle of the amplifier output

eq. 3.3.7 $$\frac{E_2 - E_{out}}{R_4} = \frac{e - E_2}{R_2} + \frac{0 - E_2}{R_5}$$

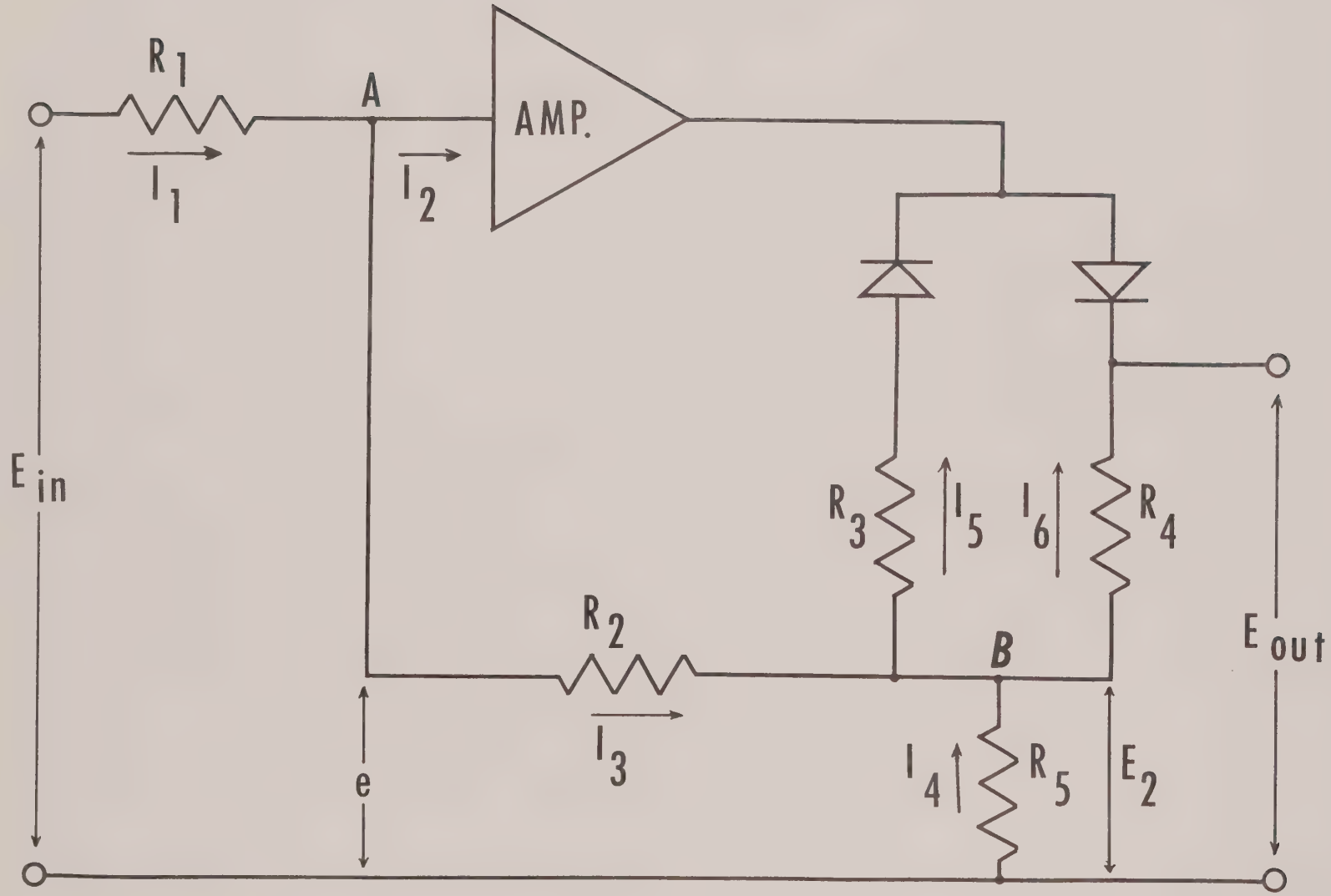
Substituting eq. 3.3.4 in eq. 3.3.7 and solving for E_{out}

eq. 3.3.8 $$E_{out} = E_2 + E_2 \frac{\frac{R_4}{R_2 R_5}}{R_2 + R_5} + \frac{E_2}{K}\frac{R_4}{R_2}$$

During the negative half cycle of the amplifier output, assuming perfect diodes:

eq. 3.3.9 $I_6 = 0$ and eq. 3.3.10 $E_{out} = E_2$

from 3.3.6 if E_{In} has no DC component E_2 has no DC component and the positive half cycle of E_2 in the first factor of eq. 3.3.8 is exactly cancelled by the negative half cycle of eq. 3.3.10



Block Diagram
A.C. to D.C. Converter
Fig. 3-3-1

In this instrument $R_4 = R_2$ and $E_2 = 1$ volt RMS

therefore the factor:

eq. 3.3.11 $$\frac{E_2}{K}\ \frac{R_4}{R_2} = \frac{1}{K}$$

and the output DC voltage equals the half wave rectified average of:

eq. 3.3.12 $$E_{out} = E_2 \frac{R_4}{\frac{R_2 R_5}{R_2 + R_5}} + \frac{1}{K}$$

substituting eq. 3.3.6 in eq. 3.3.12

eq. 3.3.13

$$E_{out} = -E_{in} \frac{R_4}{\frac{R_2 R_5}{R_2 + R_5}} \left[\frac{1}{1 + \frac{2}{K}}\right] + \frac{1}{K}$$

The ratio $\frac{R_4}{\frac{R_2 R_5}{R_2 + R_5}} = 10\,\frac{\pi}{2}$ which is the conversion factor from the RMS input voltage to the average of the half wave rectified voltage E_{out}. This factor causes E_{out} to equal 10 volts DC when E_{in} equals 1 volt RMS. Since K is equal to 2000 the half wave rectified value of 1/K equals 0.225 milli-volts and may be neglected.

Because 435 ohms was used for R_5, instead of 472 ohms as computed, the ratio of 3.3.13 will not come out correctly. While the actual values are not critical, it is important that their values remain constant.

THE DIODES:

The silicon diodes used have a back resistance of greater than 100 meg Ω and a forward resistance of less than 1000 Ω.

The forward resistance appears in series with the output of the amplifier thereby increasing its output impedance. Doubling diode resistance at this point will only cause a 10% reduction in K and diode forward resistance changes may be neglected.

The back resistance appears in shunt with R_4 and if it were to decrease from 100 megohms to 10 megohms it would cause a change of 0.1% in the output voltage.

AMPLIFIER GAIN:

From eq. 3.3.13 it may be seen that amplifier gain affects the AC to DC conversion ratio in two ways. It has been shown that for values of K of greater than 1000 the factor 1/K may be neglected. The factor $\frac{1}{1+\frac{2}{K}}$ is equal to 0.999 for a gain of 2000. If the amplifier gain drops to 1000 this factor decreases to 0.998 or a change of 0.1% in the AC to DC conversion ratio. It should be remembered that the absolute value of the AC to DC conversion ratio is not important. The value of this ratio is adjusted when the instrument is calibrated against the primary standard. The important factor is that this conversion ratio must remain constant for periods between routine calibration checks.

3-4 AUDIO FILTER:

The Audio Filter is a low pass LC filter designed to pass the average value of the half wave rectified signal from the AC to DC converter. The response of the filter is flat from DC to 20 cycles and is down 70 db at 30 cycles and retains this attenuation to beyond 20 KC. This permits the filter to pass the amplitude variations in the AC signal without allowing the regulator to respond to the ripple in the rectified signal. The resistive pad at the input of the filter isolates the rectifier circuit from the reactive impedance at the filter input.

3-5 DC REFERENCE AND SERVO AMPLIFIER:

The DC signal from the filter output is taken through a lead lag stabilization network Z101 compared with the precision DC reference by the 60 cycle contact modulator.(G 101)

The DC reference is a silicon zener diode composed of two junctions back to back with matched temperature coefficients. This diode has a

very low voltage coefficient of temperature in the zener region and the diode is mounted in a temperature controlled oven to further reduce its voltage fluctuations. The internal dynamic resistance of the diode is about 10 ohms. This means that a change of current of 0.6 ma will produce a change of 0.1% in the zener voltage of 6 volts. The zener current is derived from the regulated 150 volt supply through a resistance of 15 K ohms. A change of 11 volts in the 150 volt supply would therefore result in a change of 0.1% in the zener reference voltage.

The contact modulator G101, is a vibrating reed which mechanically switches the grid of the first stage of the servo amplifier alternately from the reference to the filter output at 60 cycles per second. This reed is driven at a phase angle of 90 degrees from the power line. The square wave output of the modulator is amplified and in the second stage of the servo amplifier converted to a sine wave by the filter Z103, in the feedback, around the tube. The gain control at the output of the second stage provides for variations in tube gain so that the servo may always be operated with a minimum of dead space. The sine wave which is proportional to the error in the AC voltage at the AVS-321 output, is further amplified and drives the servo motor to correct the error to zero. A servo motor and potentiometer are used to obtain the signal level control because this system does not introduce any distortion in the sine wave signal. The second section of the servo potentiometer is used to supply a rate feedback signal to the servo amplifier for stabilization.

3-6 POWER AMPLIFIER:

The power amplifier section is a high feedback linear amplifier designed to deliver 30 watts to a matched load with a very minimum of distortion. It consists of a triode preamplifier followed by a

grounded grid phase inverter V-704. V-705 is a push pull amplifier stage with negative feedback on its plates from the output stage. This is followed by V-706, a push pull cathode follower driver stage. The output stage is made up of four 5881's V707, V708, V709 and V710 operating in push pull parallel. The output transformer primary is divided into matched plate and cathode windings so that the stage is DC self-balancing. The output is operated in Class AB-I with current flowing in each half during approximately 300 degrees of the cycle. The output of the transformer is fed back to the cathode of the first stage, V703. The feedback in this loop is approximately 18 db.

The first stage plate is powered from a 105 volt supply regulated by the second half of V703. This supply has extremely low ripple and noise, the peak to peak value being less than 2 mv with zero signal on the amplifier.

3-7 POWER SUPPLY:

The power supply consists of three major sections. First, the the low plate supply is a source of 370 volts DC supplying two electronic regulators, (150 volt and 250 volt), and a 105 volt VR tube regulated reference supply. Second, a negative supply of 200 volts is the source of bias voltages in the AC Converter and Power Amplifier. Third, a high plate supply is the source of the 410 volt DC plate voltages on the power output tubes and through a dropping resistor supplies a 280 volt unregulated voltage to the servo amplifier.

The 150 volt and 250 volt electronic regulators are of the series pass type and are nearly identical in operation. The 250 volt pass tube is aided by another such tube in shunt.

In addition to these power sources, a 12 volt DC supply is provided to supply the input stages of both the AC Converter and Servo Amplifier with a DC heater voltage.

3-8 60 CYCLE INTERNAL OSCILLATOR:

Because small amounts of 60 cycle hum in the system will cause the output voltage to vary at the beat frequency when operating within a few cycles of 60 or 120 cycles, the AVS-321 incorporates an internal, low distortion, 60 cycle oscillator. It is a wien bridge oscillator, synchronized from the line frequency, phase shifted in such a manner so as to provide an in phase relationship between the output voltage and the 60 cycle system hum.

4-1 STANDARDS:

The Holt Instrument Laboratories AVS-321 Audio Voltage Standard is a working standard and should not be considered a primary standard of AC voltage. It is designed and constructed with the utmost care and should have no trouble in maintaining its rated stability for the recommended calibration period of thirty days. However, with any instrument employing vacuum tubes a gradual change in tube characteristics does cause a gradual shift in calibration as explained in the theory section of this manual.

Primary standards are those standards which may be reproduced anywhere in the world to a given degree of accuracy by using specified materials and construction. The Weston normal standard cell is the primary standard of DC voltage. To obtain a primary standard of AC voltage, a transfer instrument must be used. This is an instrument which because of its basic principle of operation, will respond identically to AC or DC voltages having equal RMS magnitudes. The two instruments most commonly used for this purpose are the dynamometer and the thermo-couple transfer voltmeter.

Holt Instrument Laboratories uses and recommends the Holt Instrument Laboratories, Model TV-1, for the calibration of the AVS-321.

4-2 PERIODIC CALIBRATION PROCEDURE:

The AVS-321 should be calibrated under carefully controlled laboratory conditions. Any attempt to adjust the calibration casually in the factory or test lab will almost certainly result in operation outside the accuracy specifications of the instrument.

The following equipment is recommended for the calibration of this instrument:

Audio Oscillator	See Page 2-4 for specifications
Distortion Analyzer	Hewlett Packard 330B
Oscilloscope	Tectronix 531
Transfer Standard	Holt Instrument Model TVI
Potentiometer	Leeds Northrup K3
Standard Cells	Eppley Model 100

Variac and line voltage meter, thermometer, galvanometer, etc.

PRELIMINARY:

Set the equipment up in a laboratory with reasonably clean line voltage. Excessive transients or radio frequency noise on the power line will make the calibration more difficult. Remove the AVS-321 from the cabinet and examine it for mechanical faults. Connect the units as shown in the first section of this manual, being sure that all grounds are properly connected. The use of a good earth ground is recommended. Connect the oscilloscope to the test points on the servo amplifier. TP102 is the ground point, TP101 is the servo error signal (ref. Fig. 6.6). Place AVS-321 in Operate and adjust the scope for 60 cycle sweep with line sync. The vertical gain should be set at 200 mv/cm. Move the servo gear to one side of null with your finger until a 60 cycle wave form of several hundred millivolts is displayed on the scope. Adjust the trigger level control and trigger slope to produce the wave-form shown in Figure 4-2.1.

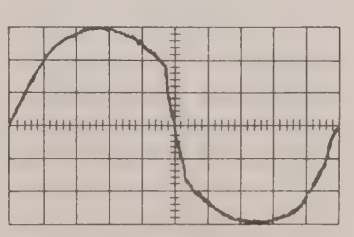


FIG. 4-2.1

Move the servo gear to the other side of null and the waveform should be as shown in Figure 4-2.2.

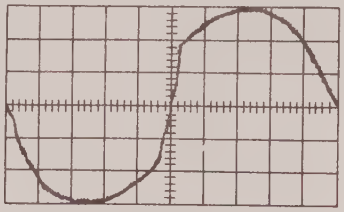


FIG. 4-2.2

Increase the scope sensitivity to 50 mv/cm. and place the AVS 321 in standby. The peak to peak value of the waveform should be less than 50 mv. Place the AVS-321 in operate. The waveform when the servo is nulled will be as shown in Figure 4-2.3. A or B.

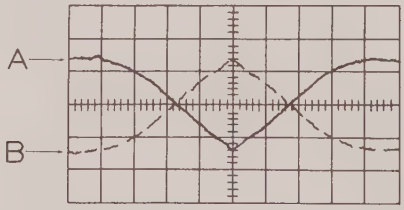


FIG. 4-23

This voltage is a quadrature component of the normal hum level and produces no torque in the motor. As amplitude transients occur in the amplifier or oscillator, the error wave-form will change as shown in Figure 4-2.4, A or B.

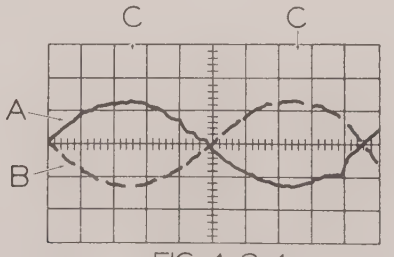


FIG. 4-2.4

These voltages have in-phase, torque producing components at Point C. This voltage will cause the servo motor to rotate returning the system to null. The fluctuation in the instantaneous voltage at points C should not exceed 50 milli-volts at frequencies above 100 cycles. Below 100 cycles this will increase due to the presence of 60 cycle hum intermodulation. It should not become greater than 150 milli-volts at frequencies down to 35 cycles.

DISTORTION:

Check the distortion at the output of the AVS-321 at 290 volts and frequencies of 35 cycles, 1 KC and 10 KC. The total distortion due to all parts of the system (oscillator included), should be less than 0.25%. If necessary, adjust the distortion balance of the power amplifier on the 5881 chassis for minimum distortion. Also check tubes V703 through V710.

DYNAMIC RESPONSE:

Slow the sweep of the scope to its minimum. Change the oscillator output 1 db by switching the attenuator switch on the oscillator. The error signal on the scope should return to within 100 milli-volts in less than 0.4 seconds.

VOLTAGE CALIBRATION:

Set the AVS-321 for 1 volt output at 1,000 cycles. Rotate the right hand voltage dial several times, then set it at extreme clockwise position. The line voltage should be at 115 volts; ambient temperature 20 to 30 degrees centigrade. Allow at least one hour to warm up. Check the output carefully using the transfer voltammeter. If necessary, correct the voltage to 1 volt by adjustment of R104, the small DC reference trim pot inside the shield can at the top of the servo amplifier chassis. Adjust the 10

volt output using R-325, the trim pot at the top of the AC to DC Converter Chassis.

FREQUENCY RESPONSE:

Check the frequency response of the 10 volt range from 35 cycles to 10 KC. Small amounts of 60 cycle hum in the system will cause the output voltage to vary at the beat frequency when operating within a few cycles of 60 or 120 cycles. The peak to peak swing of these variations should be less than 0.1%. Operation exactly on 60 cycles or 120 cycles should be error free. Some of this variation may be due to the oscillator and some is contributed by intermodulation in the power amplifier.

It is unlikely that frequency response will need adjustment in the field unless some of the components on the AC to DC converter board become defective. If output voltage is out of specification see "Set and compensate", Page 5-8.

5-1 OVERHAUL AND COMPLETE CALIBRATION PROCEDURE:

Prior to shipment, the AVS-321 is accurately calibrated under carefully controlled laboratory conditions. Naturally the manufacturer recommends that future calibrations be similarly conducted. Any attempt to casually adjust the calibration will most certainly result in operation outside of the accuracy specifications of the instrument.

The following equipment is recommended for the calibration procedure:

Audio Oscillator ..... See Page 2-4

Distortion Analyzer ... Hewlett Packard Model 330B

Oscilloscope ..... Tektronix Type 531

Transfer Standard ..... Holt Instrument Lab Model TVI

Potentiometer ..... Leeds Northrup K2 or K3
Otto Wolff KF-4 or KF-5

Standard Cells ..... Eppley Model 100

Vacuum Tube Voltmeter.. 11 meg ohm input resistance
3% full scale accuracy.

Wheatstone Bridge ..... Otto Wolff 944

Variac, line voltage meter, thermometer, galvanometer, etc.

VISUAL INSPECTION:

With power off, visually check for shorts, poor solder joints, loose or broken wires, missing or burnt components, etc. Oil fan every 6 months.

MINIMIZE SERVO MOTOR AND POTENTIOMETER MECHANICAL FRICTION:

The maximum motor, gear and pot friction is 3 inch ounces on the potentiometer shaft. Should this be excessive, remove the motor gear and check the motor and pot independently. If neither seems excessive, the gear mesh itself can be adjusted by loosening the set

screw in the eccentric bearing on the pot shaft. By slowly turning the eccentric, the degree of gear mesh can be optimized to give quiet, close mesh with a minimum of friction. Reset the set screw after completing the adjustment.

SET THE .01 VOLT DECADE VARIABLE RESISTOR:

Connect a bridge or ohmmeter that draws less than 50 ma. across the variable resistor, (R-644). Set the stop so that the resistance at the clockwise extremity is zero and there are no discontinuities between zero and maximum resistance. Loosen the knob set screw and turn the dial to zero with the resistor set at its clockwise extremity.

BRIDGING PRECISION RESISTORS:

Ground the point between R-301 and C-304 on the AC-DC Converter subassembly. Disconnect the lead on the wiper of S-600-D in the attenuator. Connect the bridge between this point on S-600-D and common. See Figure 5.1.1. for dial settings and corresponding resistances. All resistors should be within three hundredths of a percent of the indicated value.

To bridge the precision resistors on the AC Converter subassembly simply remove all the jumpers soldered between test points throughout the circuit. Also disconnect AC Converter from the attenuator. This procedure isolates all circuit segments containing precision resistors allowing them to be accurately measured. Again refer to Figure 5.1.1. for proper value of each resistor. Refer to original data sheet that accompanies each instrument for factory readings.

OPERATIONAL CHECK ON POWER SUPPLIES:

Plate and Bias Supplies - Place AVS-321 "on" and in "Stand-by". With a VTVM read the following test points. At the same time observe the ripple voltage with the oscilloscope and compare to the

HOLT INSTRUMENT LABORATORIES

PRECISION RESISTOR VALUES AVS-321

A.C. CONVERTER

R-103	2,667
R-104	200
R-105	3,333
R-324	305
R-301	10,000
R-302	10,000
R-320	10,000
R-321	10,000
R-322	435
R-401	100,000
R-402	50,000

ATTENUATOR

RANGE	RESISTANCE	RANGE	RESISTANCE
	Adjust R-325		
1.0	for 300 ohms	20.0	6,000
1.1	330	30.0	9,000
1.2	360	40.0	12,000
1.3	390	50.0	15,000
1.4	420	60.0	18,000
1.5	450	70.0	21,000
1.6	480	80.0	24,000
1.7	510	90.0	27,000
1.8	540	100.0	30,000
1.9	570	110.0	33,000
2.0	600	200.0	60,000
3.0	900	300.0	90,000
4.0	1,200	400.0	120,000
5.0	1,500	500.0	150,000
6.0	1,800	600.0	180,000
7.0	2,100	700.0	210,000
8.0	2,400	800.0	240,000
9.0	2,700	900.0	270,000
10.0	3,000	999.99+	300,000
11.0	3,300		

Figure 5.1.1

waveforms, Figures 5.1 through 5.10. The regulating ability of the 150 and 250 volt electronic regulators can be observed by lowering and then raising the line voltageten percent above and below the 115 volt operating point while monitoring the regulated voltages for loss of regulation. At 115 volt line voltage, check the following DC voltage Supplies:

C-201 B ..... 385 volts DC
V-202 pin 1 ..... 105 volts DC
C-203 B .....Neg. 200 volts DC
C-207 B ..... 410 volts DC
P-203 pin 2 ..... 150 volts DC
P-202 pin 1 ..... 250 volts DC
C-206 Terminal ..... + 6 volts DC
C-206 Can ..... - 6 volts DC

The damping voltage is measured between R-280 and R-249 on the underside of the AVS-321 chassis. Proper voltage lies between 12.0 and 15.0 volts DC. See original data sheet for factory readings.

READ ALL DC VOLTAGES:

With a VTVM read all DC tube voltages indicated on DC voltage charts Pages 5.17 through 5.19 See original data sheet for factory readings.

CENTER FRONT PANEL METER FOR ONE VOLT RMS:

Connect a low distortion oscillator to the input terminals and monitor the input signal magnitude with a reliable meter. Set the oscillator for 1000 cycles and 1 volt RMS. The front panel meter on the AVS-321 should read 1 volt as well. The meter can be adjusted by turning the screw adjustment on the face of the meter movement.

ROUGH CHECK THE OUTPUT VOLTAGE:

Connect an AC meter capable of reading voltages up through 1000

volts, to the output terminals of the instrument with servo gain control (R118) turned fully counter-clockwise. Place AVS-321 in "operate." With one volt input at 1000 cycles, select an output of one volt and read the output. Increase each decade switch in turn constantly watching the output. This check merely verifies the proper transformer connections and in no way is a calibration procedure.

PERFORM OPERATIONAL CHECKS ON THE SERVO AMPLIFIER AND AC CONVERTER:

If the DC voltages are normal throughout both the servo amplifier and the AC converter, turning servo gain control (R118) clockwise should cause the servo to seek its null point. See "Setting servo gain" Page 2.7. If some malfunction still exists, use the following procedure. Turn the servo amplifier gain (R118) fully counter-clockwise.

Manually turn large servo gear until one volt RMS is being fed to the input stage of the converter. With the oscilloscope, check the signal after either CR 301 or CR 302. The signal should be 28 to 33 volts peak to peak, each 180 degrees displaced from the other. The waveform should be as indicated in Fig. 5.20. If the portion along the reference line shows other than a smooth curve, as shown in the incorrect portion, then CR 301 and CR 302 should be checked and replaced. This irregularity will cause the frequency response to shift and also the output of the AVS-321 to become incorrect. The output of the filter as fed to the servo amplifier should be flat with a DC level of 3 to 4 volts.

If everything is operational up to this point, remove the chopper (G101) from its socket. Trace the filter output from the converter board through Z 101 to pin 1 of the chopper socket. With a VTVM read at pin 1 of chopper socket between 3 to 4 volts DC. Rotating servo gear clockwise by hand will cause this voltage to rise. With a VTVM read the zener reference voltage at pin 8 of the reference oven (Z 102).

The proper voltage is between 6 and 7 volts DC. The exact voltage is given in the test data sheets for each AVS-321. This is read by bucking 6 standard cells in series with a precision potentiometer and galvo to obtain the difference reading. The total of the cell voltages and potentiometer reading equals the zener voltage. Read the reference voltage at pin 3 of the chopper socket. Its value depends on the setting of R-104 but is between 3 and 4 volts DC. The exact voltage at time of calibration is given in the test data sheets. This is measured by the bucking method also but using only 3 cells. The negative lead for these measurements should be connected to TP 102, the upper test point.

After measuring these voltages, reinsert the chopper and replace the cap.. Be certain the chopper coil is being driven at about $6\frac{1}{2}$ volts, and is sampling properly by observing its output with a scope at 10 millivolt sensitivity, at pin 2 of the chopper socket. Pulling the servo gear about a quarter turn from null position will produce a 60 cycle square wave of about 20 milli-volts peak to peak. It will have small spikes as shown in waveform Fig. 5.25. The chopper output undergoes a voltage gain of approximately 1200 to the error signal test point, TP 101. If this gain is normal, adjust the servo gain control (R118). See "Setting servo gain", Page 2.7. Should the servo still fail to operate properly, refer to Page 5-16 for testing of V 101.

Then disconnect the arm of the servo gain pot (R118) and connect a 60 cycle sinusoidal signal of about 15 milli-volts to pin 2 of V 102. With the motor rotor held stationary, the transformer T101 secondary voltage should be about 9 volts peak to peak and appear as a good sine wave. Decrease signal to zero and release the gear. With the motor rotor free, increase the signal at pin 2 from zero to 15 milli-volts.

If the motor does not start to turn or it takes more than 15 millivolts to start it, check the motor, gears and potentiometer for excessive mechanical friction. (See "Minimize servo motor friction", Page 5-1) Let the input frequency drift one or two cycles above or below the line frequency. The servo motor should run first one way and then the other. When the motor is running, the secondary of the transformer should rise to about 90 volts peak to peak. Disconnect the signal and reconnect circuit to arm of servo gain potentiometer R118.

READ HUM LEVEL:

Turn the servo gain completely counter-clockwise, disconnect the oscillator, place a 560 ohm resistor across the input terminals, select 290 volt output. Using the Hewlett Packard 330B, read the output, which is all hum, and it should be at least 60 db below the 290 volts.

READ AND MINIMIZE HARMONIC DISTORTION:

With the instrument operating at 10 volts nominal output, connect the Hewlett Packard 330B. Read the distortion at a number of frequencies between 35 cycles and 10,000 cycles. The total harmonic distortion should be less than .15% added to oscillator distortion. If necessary, adjust the distortion control (R709) on the power amplifier subassembly. Also check all tubes in amplifier and check output tubes for balance.

READ FEEDBACK LEVEL:

With no signal applied and the servo gain control (R118) turned completely counter-clockwise, disconnect the feedback lead at the junction of C708 and R733 in the power amplifier. Select 10 volts output and at various frequencies from 35 to 10,000 cycles gradually increase input level until output reaches 10 volts. (Caution: With no feedback the gain of the amplifier is considerably greater. As a result, about 0.1 volt input will produce the desired output. Never exceed the selected output.) Connect the feedback loop and read the new output voltage.

The desirable level of attenuation is between 17 and 20 db. See factory data sheet for original values. If necessary substitute V703 through V706 to achieve this level.

CHECK AMPLIFIER STABILITY:

Connect the oscilloscope to the 250 volt regulated supply, on pin 6 of V205. Set the scope sensitivity for about one volt per centimeter. Rapidly and repeatedly switch the operate-stand-by switch back and forth, observing the oscilloscope for any tendency toward sustained high frequency oscillations. Reconnect the oscilloscope to the output terminals and repeat the above procedure with the load switch set at 6 watts. The presence of oscillations are an indication of amplifier instability sometimes due to excessive feedback, very high gain tubes in preamp, or an incorrect value of C 708.

SET AND COMPENSATE 1 VOLT RANGE FOR HIGH FREQUENCY:

To properly accomplish 1 volt calibration, a Holt Instrument Lab Model TV-1 Transfer Voltmeter is used in factory calibration. The 1 volt level is set with a 1000 cycle input signal, by adjusting the reference trim pot (R 104) so that the output exactly equals 1.0000 volt. The frequency response is then checked from 1000 cycles to 10,000 cycles. If at any point the output voltage varies in excess of 0.03%, the high frequency compensation can be adjusted. (R307, C307). These components have little or no effect on the output at 1000 cycles.

SET AND COMPENSATE FOR LOW FREQUENCY:

Connect a 1000 cycle signal to input. Set the output voltage dial to 10 volts. Connect the output to a calibrated transfer voltmeter. Adjust R 325 trim pot, on the AC to DC converter board, so that the output is 10.000 volts. The frequency response is then checked from 35 cycles to 1000cycles. If at any low frequency the output voltage varies in excess of 0.03%, then adjust the low frequency compensation

(R 323, R 326, C 311). At an input frequency of about 60½ cycles, small amounts of 60 cycle hum in the system will cause the output voltage to vary at the beat frequency.

The mean value of this peak-to-peak variation should nearly equal 10.000 volts; if it does not, accurate setting of the 60 cycle internal oscillator will be impossible.

The low frequency compensation, although set at one particular voltage, is effective for any output voltage. The adjustment of R325 sets the 1000 cycle level of all voltages from 1.1 volts to 1000 volts. These voltages are controlled by the ratios of the precision attenuator resistors and should be within ± 0.05% of the attenuator setting at 1000 cycles.

ADJUST THE FREQUENCY, LEVEL AND DISTORTION OF THE 60 CYCLE INTERNAL OSCILLATOR:

Adjust the level until the front panel meter reads exactly one volt RMS. Then adjust the distortion control for minimum harmonic distortion at the output terminals. Since the level and distortion controls are in series there is some interaction. Subsequently, it may be necessary to adjust each alternately until the optimum is reached.

Connect the oscilloscope to pin 7 of V 210. Set the sweep for 60 cycle line sync. With the Holt Instrument Lab. Model TV-1 connected to the output and the instrument operating at 10 volts from the internal oscillator, adjust frequency control (R262) until the output reaches 10.000 volts. If the oscillator approaches the pullout point before the correct output is reached, it will be necessary to change the phase of the synchronizing voltage. A 90 degree phase shift is attained by interchanging the leads to R 281 and C 266. A 180 degree phase shift is possible be reversing all of the heater leads at the transformer secondary, T 205, pins 9 and 10.

POWER SUPPLY

WAVEFORMS

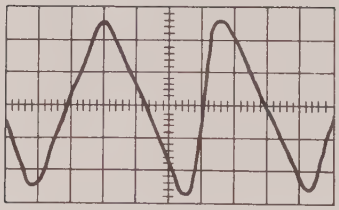


FIG. 5.1

C 201 B
0.2 V PER DIV.
2 MILLISEC PER DIV.

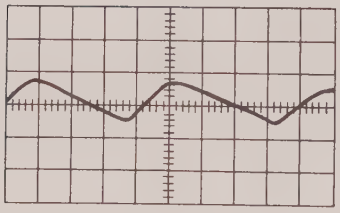


FIG. 5.2

V 202 Pin 1
.01 V PER DIV.
2 MILLISEC. PER DIV.

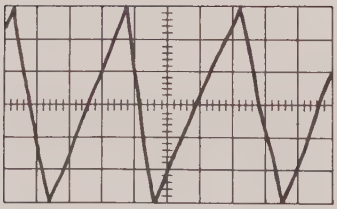


FIG. 5.3

C 203 B
0.2 V PER DIV.
5 MILLISEC. PER DIV.

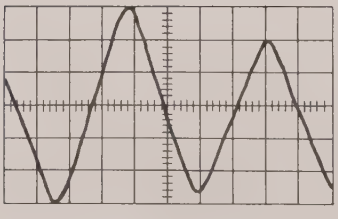


FIG. 5.4

C 207 B
0.5 V PER DIV.
2 MILLISEC PER DIV.

150 VOLT REGULATOR

WAVEFORMS

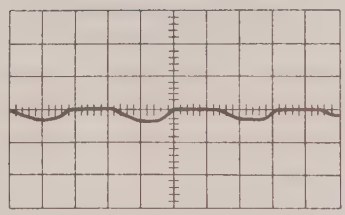


FIG. 5.5

P 203 PIN 2
0.01 V PER DIV.
5 MILLISEC PER DIV.

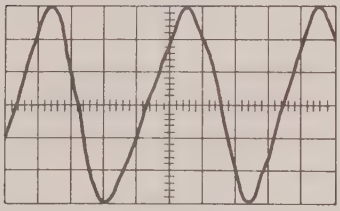


FIG. 5.6

V 213 PIN 6
0.01 V PER DIV.
2 MILLISEC PER DIV.

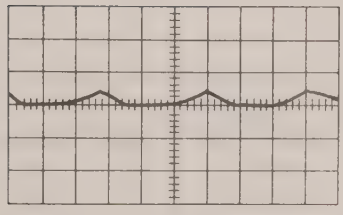


FIG. 5.7

V 208 PIN 2
0.01 V PER DIV.
5 MILLISEC PER DIV.

250 VOLT REGULATOR

WAVEFORMS

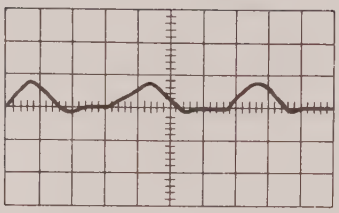


FIG. 5.8

P 202 PIN 1
0.01 V PER DIV.
5 MILLISEC PER DIV.

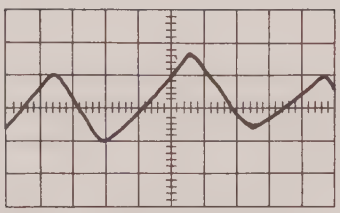


FIG. 5.9

V 212 PIN 6
0.02 V PER DIV.
2 MILLISEC PER DIV.

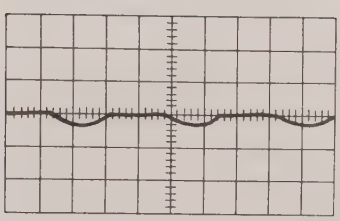


FIG. 5.10

V 205 PIN 2
0.01 V PER DIV.
5 MILLISEC PER DIV.

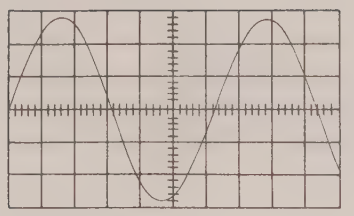


FIG. 5.11
V 703 PIN 7
1.2 V PEAK TO PEAK
SIGNAL FREQUENCY
* TAKEN WITH A LOW CAPACITY PROBE.

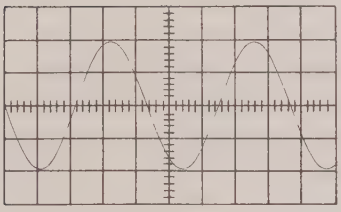


FIG. 5.12
V 703 PIN 6
AMPLITUDE BETWEEN 4 AND 6 VOLTS P. TO P. DEPENDENT ON FEEDBACK SIGNAL FREQUENCY
* TAKEN WITH A LOW CAPACITY PROBE.

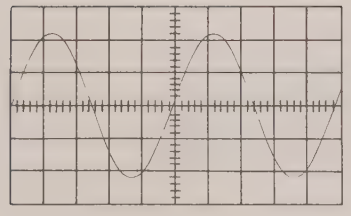


FIG. 5.13
V 704 PIN 6
22 V PEAK TO PEAK
SIGNAL FREQUENCY
* TAKEN WITH A LOW CAPACITY PROBE.

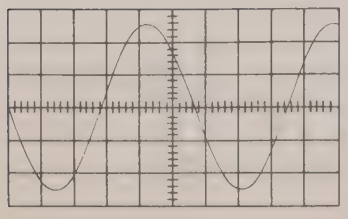


FIG. 5.14
V 705 PIN 6
250 V PEAK TO PEAK
SIGNAL FREQUENCY

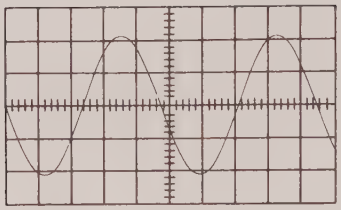


FIG. 5.15

V-706 Pin 8
240 Volts Peak to Peak
Signal Frequency

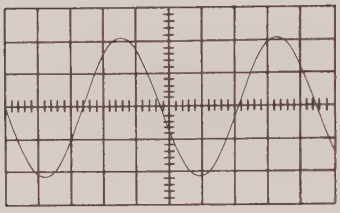


FIG. 5.16

V-709 Pin 8
V-710 Pin 8
215 Volts Peak to Peak
Signal Frequency

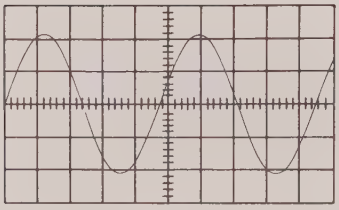


FIG. 5.17

V-709 Pin 3
V-710 Pin 3
215 Volts Peak to Peak
Signal Frequency

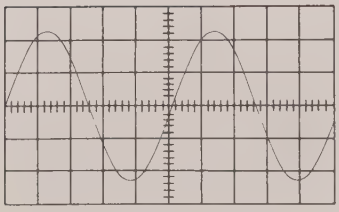


FIG. 5.18

V-703 Pin 8
.9 Volt Peak to Peak
Signal Frequency

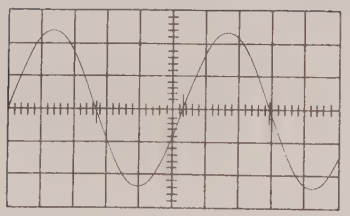


FIG. 5.19

V-302 Pin 5
1.4 Volts Peak to Peak
Signal Frequency
* Note spikes at zero crossover

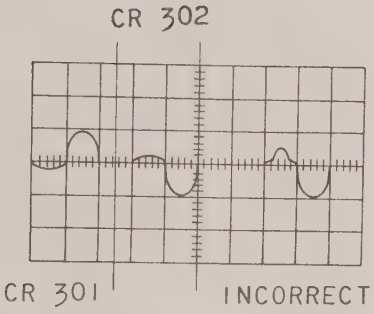


FIG. 5.20

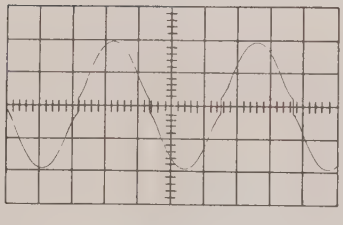


FIG. 5.21

V-304 Pins 3 & 6
76 volts Peak to Peak
Signal Frequency
* Note zero jumps.

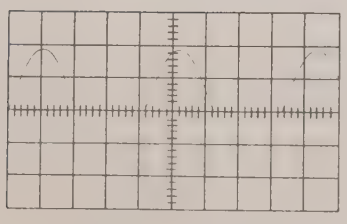


FIG. 5.22

T. P. 306
33 volts Peak to Peak
Signal Frequency

SERVO AMPLIFIER WAVEFORMS

The following two waveforms are taken under test conditions. Normally the amplitude is a function of error amplitude and the waveform is actually distorted. However, it may become necessary to determine the operational capabilities of this stage. To do so follow this test procedure:

1. Unit in Standby
2. Chopper removed from its socket
3. A 10 millivolt peak to peak, 60 cycle signal applied at Pin 2 of V-101.
4. Observe waveforms in accordance with Figs. 5.23 and 5.24

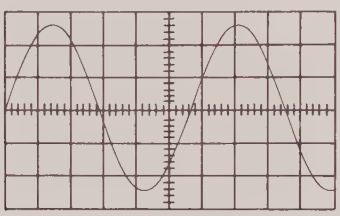


FIG. 5.23

V-101 Pin 1
.44 Volts Peak to Peak
60 cycles per sec.

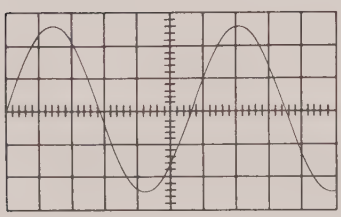


FIG. 5.24

V-101 Pin 6
9 Volts Peak to Peak
60 cycles per sec.

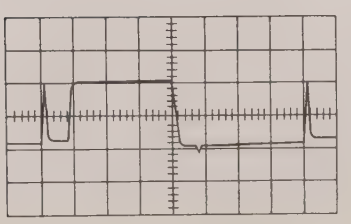


FIG. 5.25

PIN 2 CHOPPER
.01 VOLT PER DIV.
2 MILLISEC. PER DIV.

DC VOLTAGES
SERVO AMP.

FIG. 5.26

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V101	12AX7	50	-.4	-.35	0	0	100	0	1.4	+6.2
V102	12AX7	78.	0	1.1	6.3 VAC	6.3VAC	75	0	1.1	0
V103	6AQ5	0	17	0	6.3 VAC	270	280	0		
V104	6AQ5	0	17	0	6.3 VAC	270	280	0		

DC VOLTAGES
AC-DC CONVERTER

FIG. 5.27

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V301	6136	-2.5	0	0	-6.0	110	150	0		
V302	6AU6	-2.0	0	0	6.3 VAC	85	150	0		
V303	6AU6	-2.0	0	0	6.3 VAC	110	150	0		
V304	5687	245	110	115	6.3 VAC	6.3VAC	115	110	0	245

DC VOLTAGES
PRE-AMPLIFIER

FIG. 5.28

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V701	6AB4	245	NC	6.3VAC*	0*	245	0	4.3		
V702	0B2	NC	NC	NC	-105	0	NC	-105		
V703	12AX7	109	-.7	0	0*	0*	97	0	1.3	6.3VAC*
V704	12AU7	215	-7**	100	0*	0*	206	-7**	100	6.3VAC*
V705	12AU7	300	0	17	0*	0*	300	0	17	6.3VAC*
V706	12AX7	410	-33	-32	0*	0*	410	-33	-32	6.3VAC*

*Measured from Pin 4 V703
**Measured from Pin 3 V704

DC VOLTAGES
POWER AMPLIFIER

FIG. 5.29

TUBE	TYPE	PIN NUMBERS								
		1	2 to 7	3	4	5	6	7	8	9
V707	5881	NC	6.3 AC	410	405	-32	NC	4.5	3.5*	
V708	5881	NC	6.3 AC	410	405	-32	NC	4.5	3.5*	
V709	5881	NC	6.3 AC	410	405	-32	NC	4.5	3.5*	
V710	5881	NC	6.3 AC	410	405	-32	NC	4.5	3.5*	

*Measured across 50 ohm cathode resistor with signal input.

DC VOLTAGES
+ 150 AND + 250 REGULATORS

FIG. 5.30

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V205	12AX7	83	-.12	1.0	0	0	135	0	0	6.3VAC
V212	12AV7	95	-3.5	0	0	0	137	-3.5	0	6.3VAC
V203	12AV7	270	137 .8*	137 1.4*	0	0	270	137 .8*	137 1.4*	6.3VAC
V209	12AV7	270	137 .8*	137 1.4*	0	0	270	137 .8*	137 1.4*	6.3VAC
V208	12AX7	83	-1.3***	-19	0	0	135	-1.3***	-19	6.3VAC
V213	12AV7	95	-3.5	0	0	0	137	-3.5	0	6.3VAC
V206	12AV7	270	43 -1.5**	46 1.4**	0	0	270	43	46 1.4**	6.3VAC

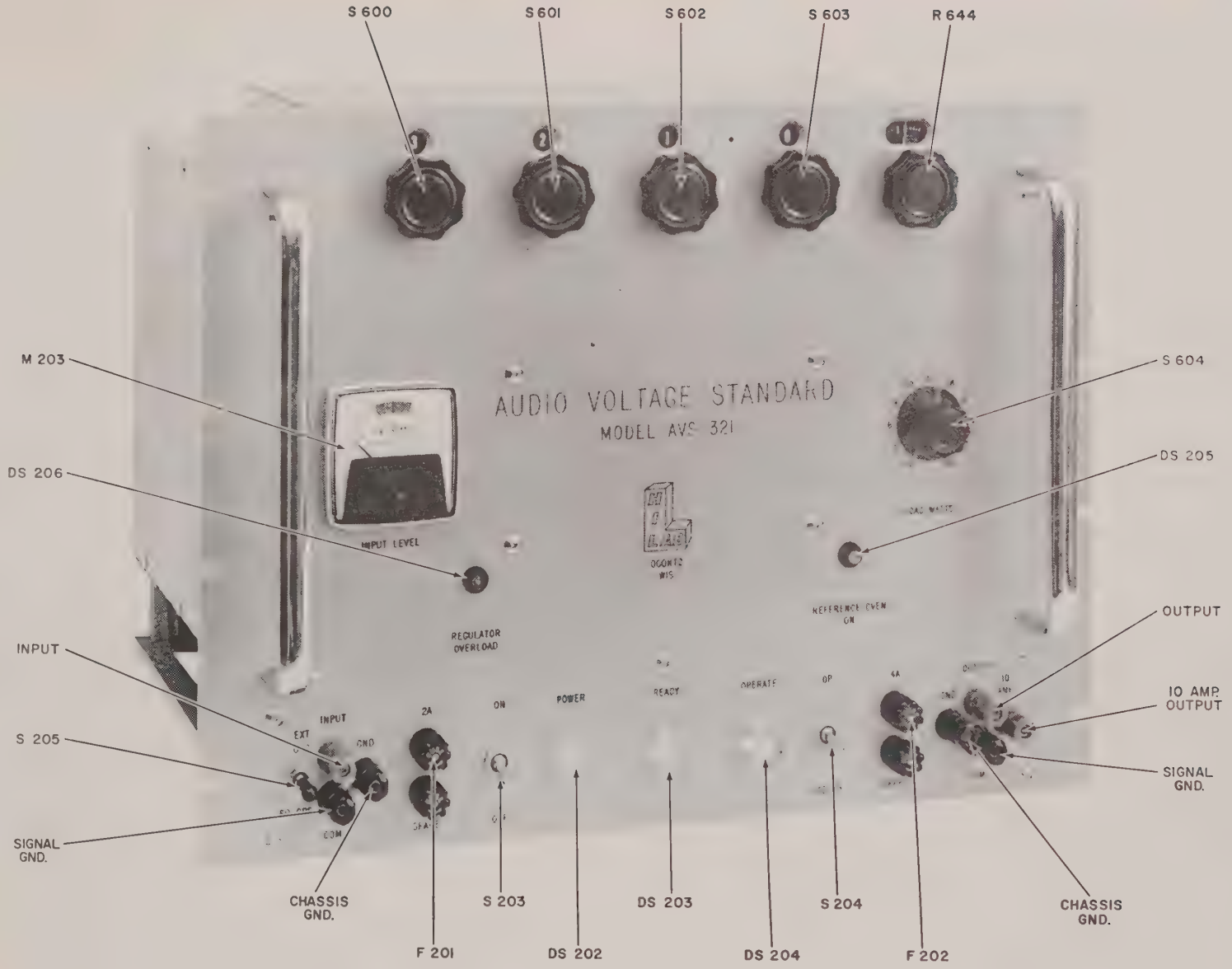
NOTE: All measured from Pin 3, V212 or V213 except those listed below:

* Measured from Pin 6 V205
** Measured from Pin 2 PL203
*** Measured from Pin 3 V208

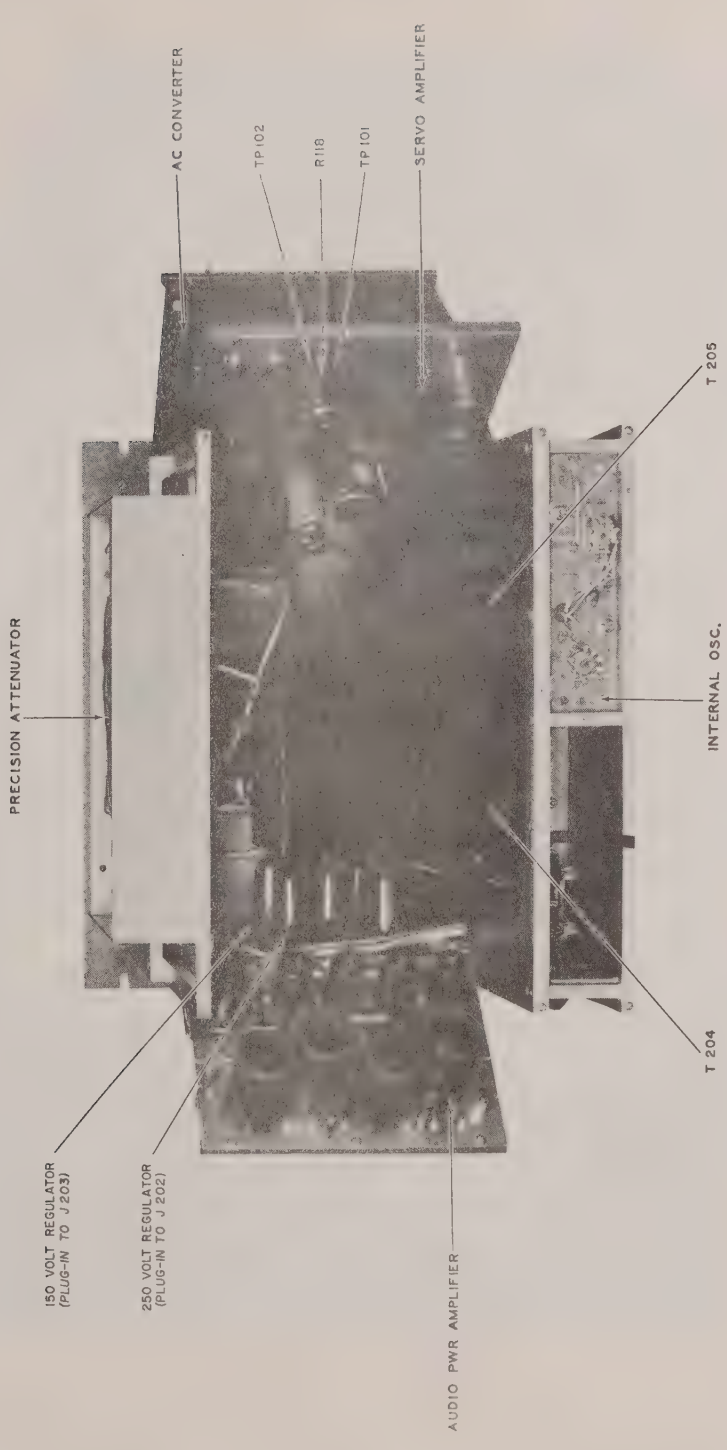
DC VOLTAGES
60 CYCLE OSCILLATOR

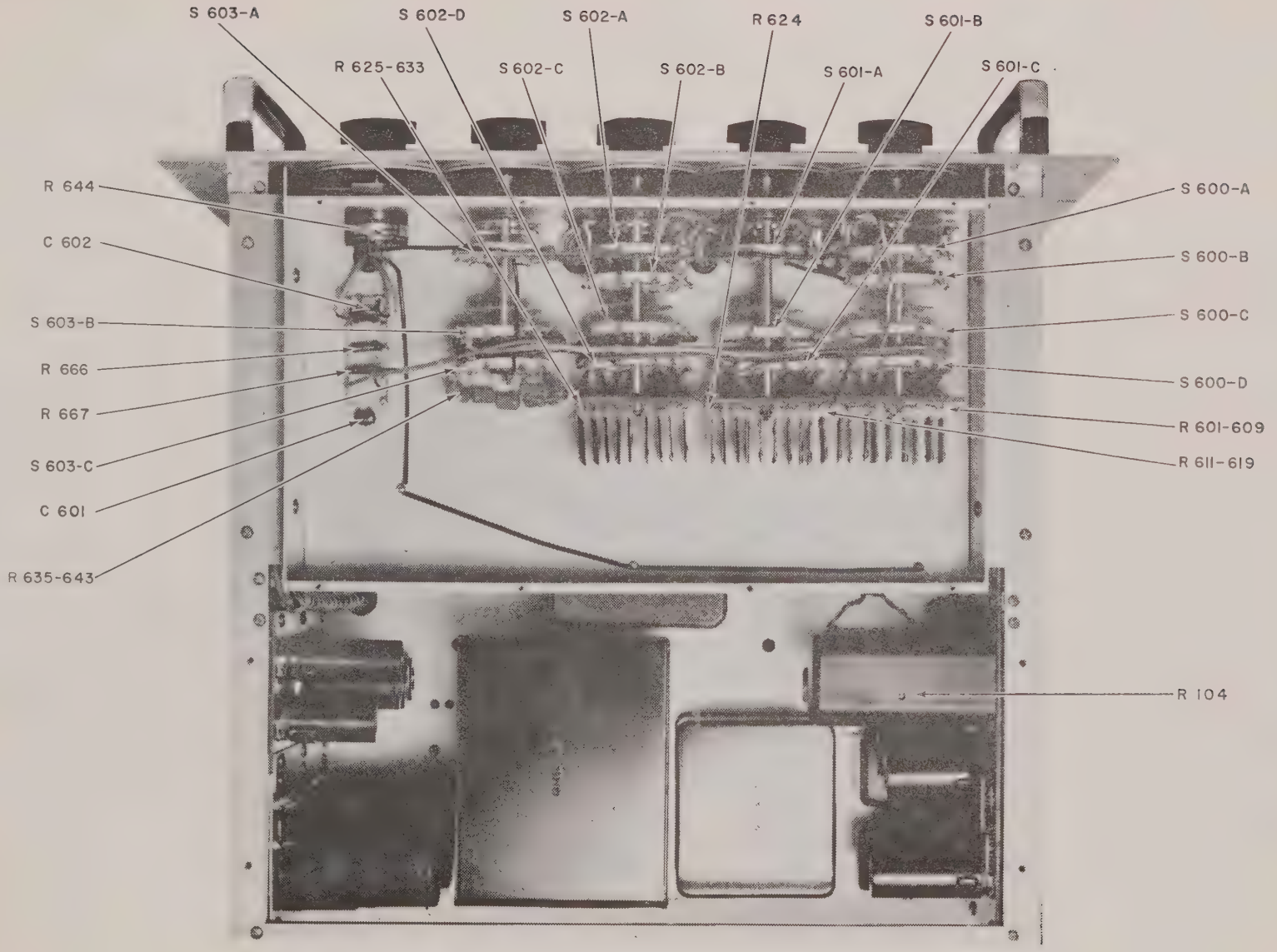
FIG. 5.31

TUBE	TYPE	PIN NUMBERS								
		1	2	3	4	5	6	7	8	9
V210	6AU6	3.8	7.1			119	148	7.1		
V211	5687	230	100	104	105	105	3.7	0	105	104

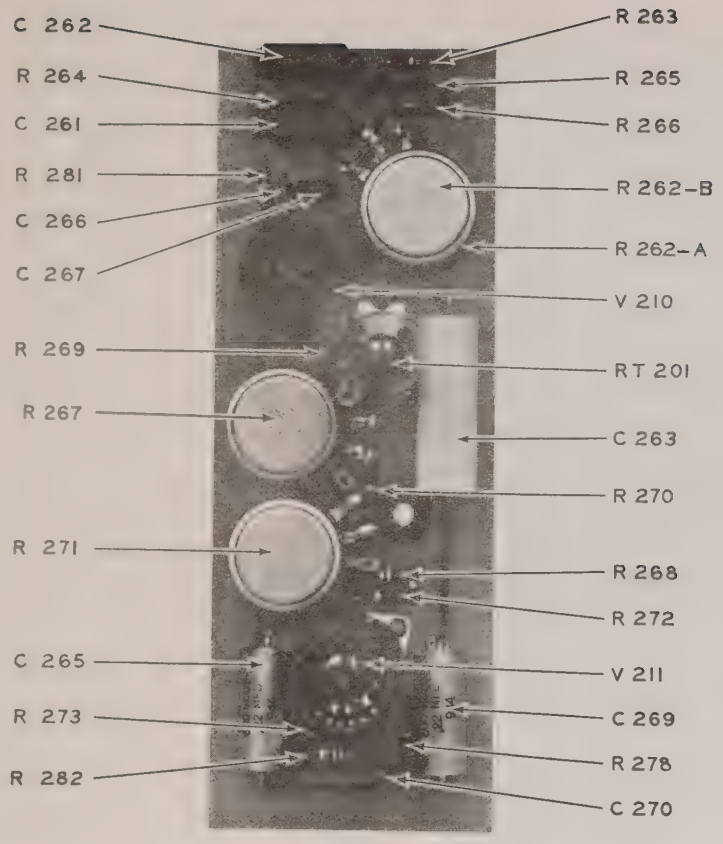


Front view - Fig. 6.1

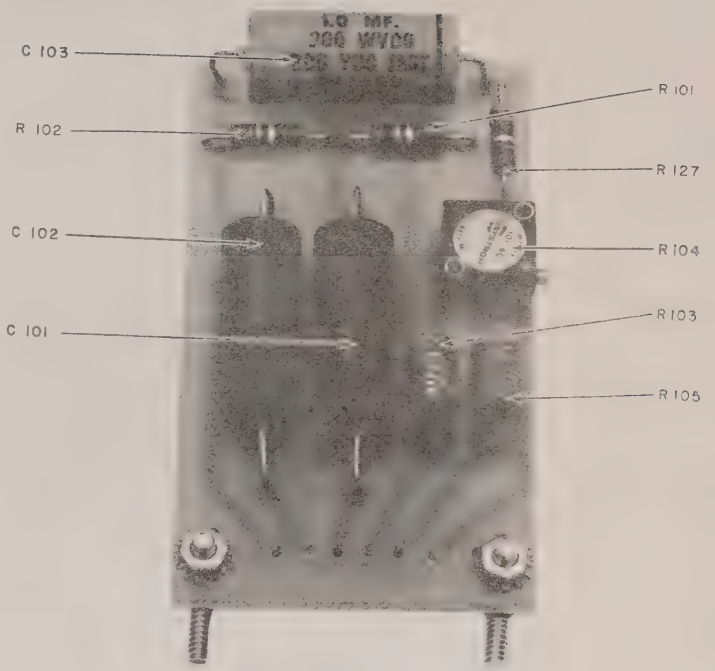

AC CONVERTER
TP102
R118
TP101
SERVO AMPLIFIER
T 205
PRECISION ATTENUATOR
INTERNAL OSC.
T 204
150 VOLT REGULATOR
(PLUG-IN TO J203)
250 VOLT REGULATOR
(PLUG-IN TO J202)
AUDIO PWR AMPLIFIER



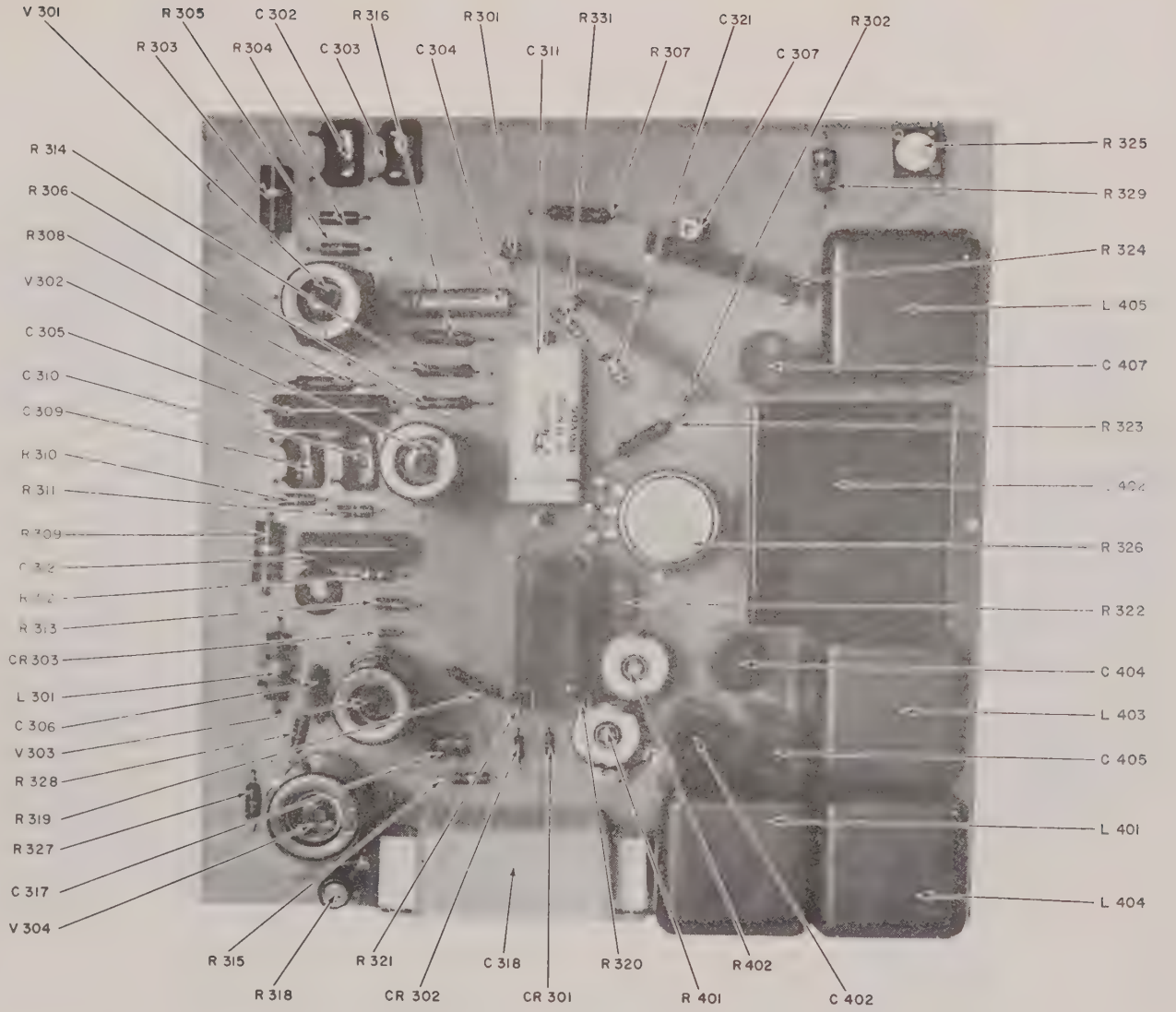
Top view - Fig 6.3



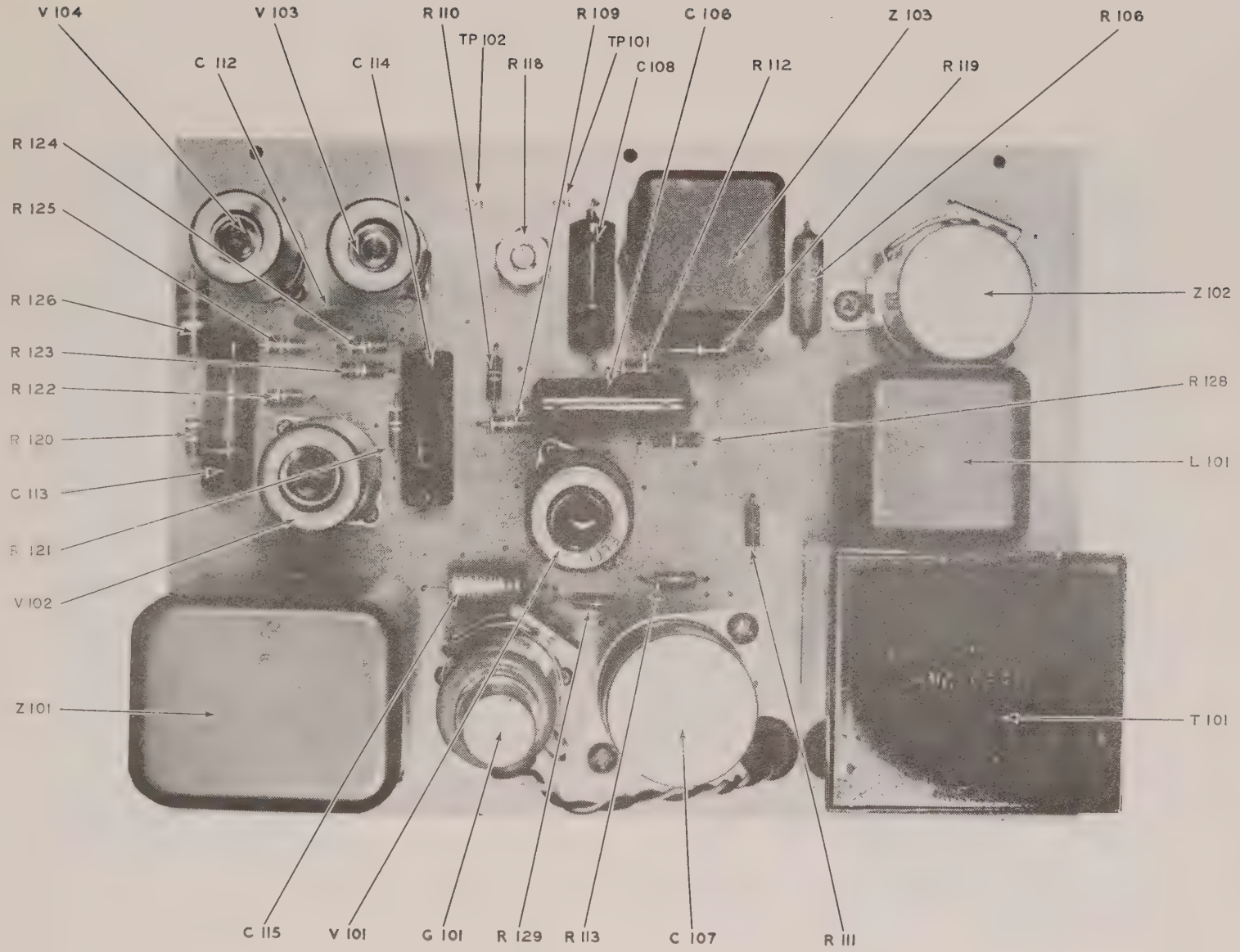
(Int. Osc. 6.4)



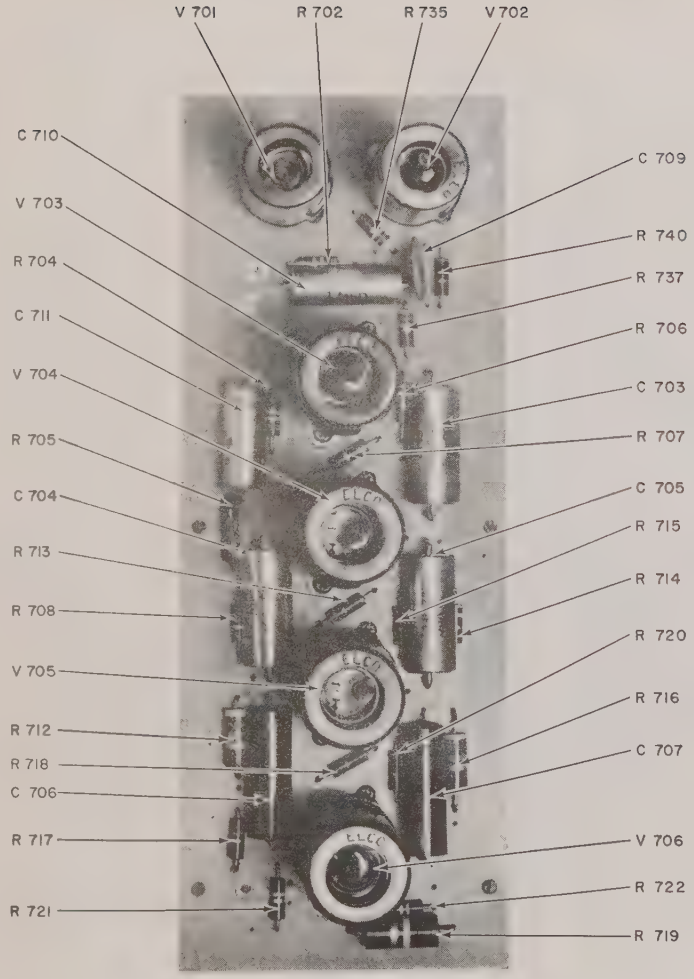
(Chopper Input 6.5)



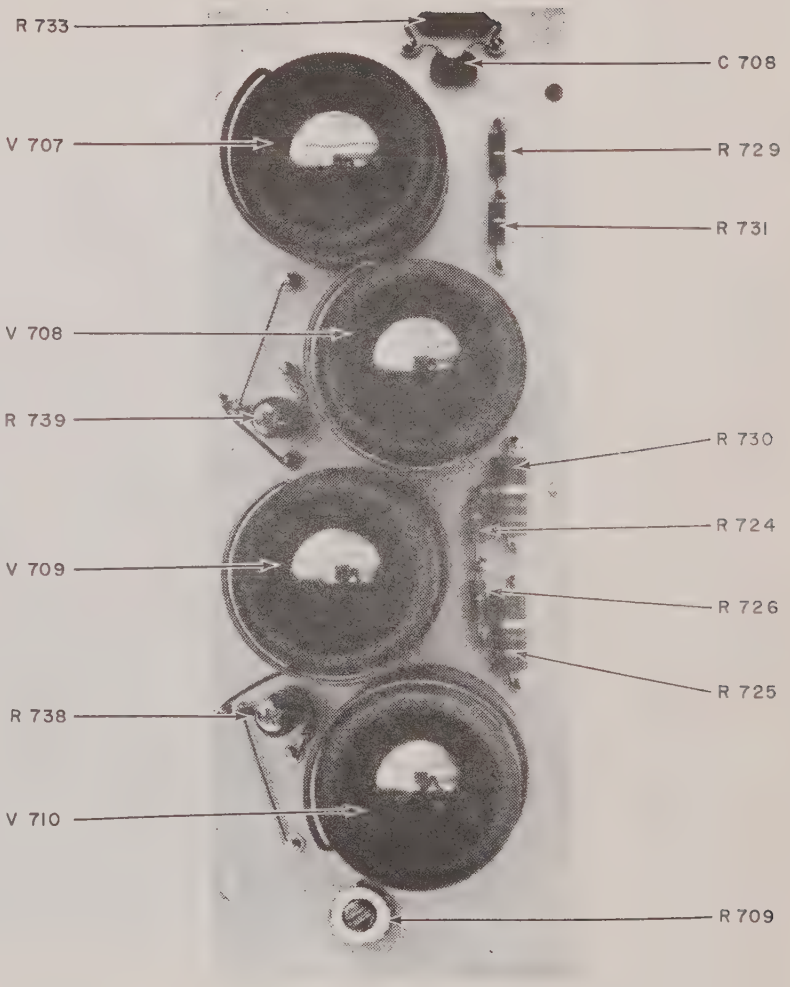
AC Conv. Fig 6.6


V 104
V 103
R 110
TP 102
R 109
TP 101
C 106
Z 103
R 106
C 112
C 114
R 118
C 108
R 112
R 119
R 124
R 125
R 126
R 123
R 122
R 120
C 113
R 121
V 102
Z 101
Z 102
R 128
L 101
T 101
C 115
V 101
G 101
R 129
R 113
C 107
R 111

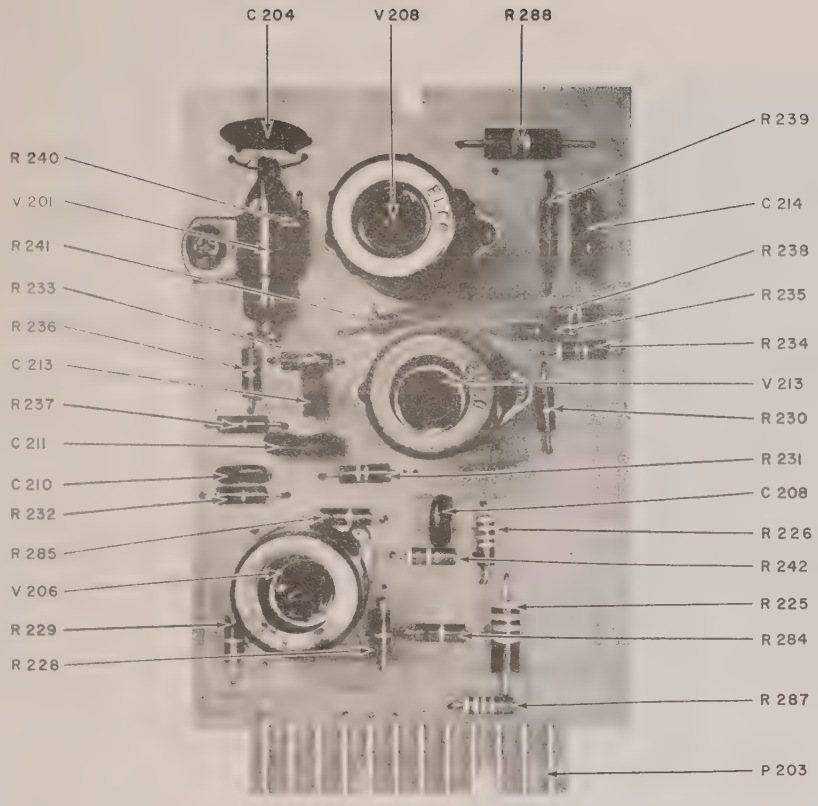
Servo Fig. 6.7



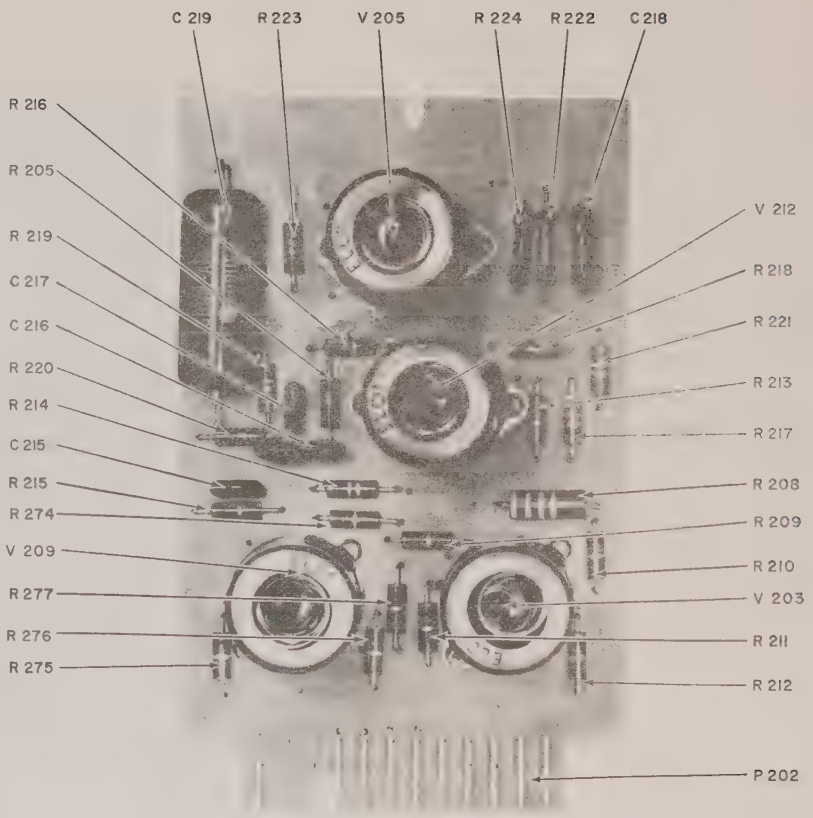
(Preamp 6.8)



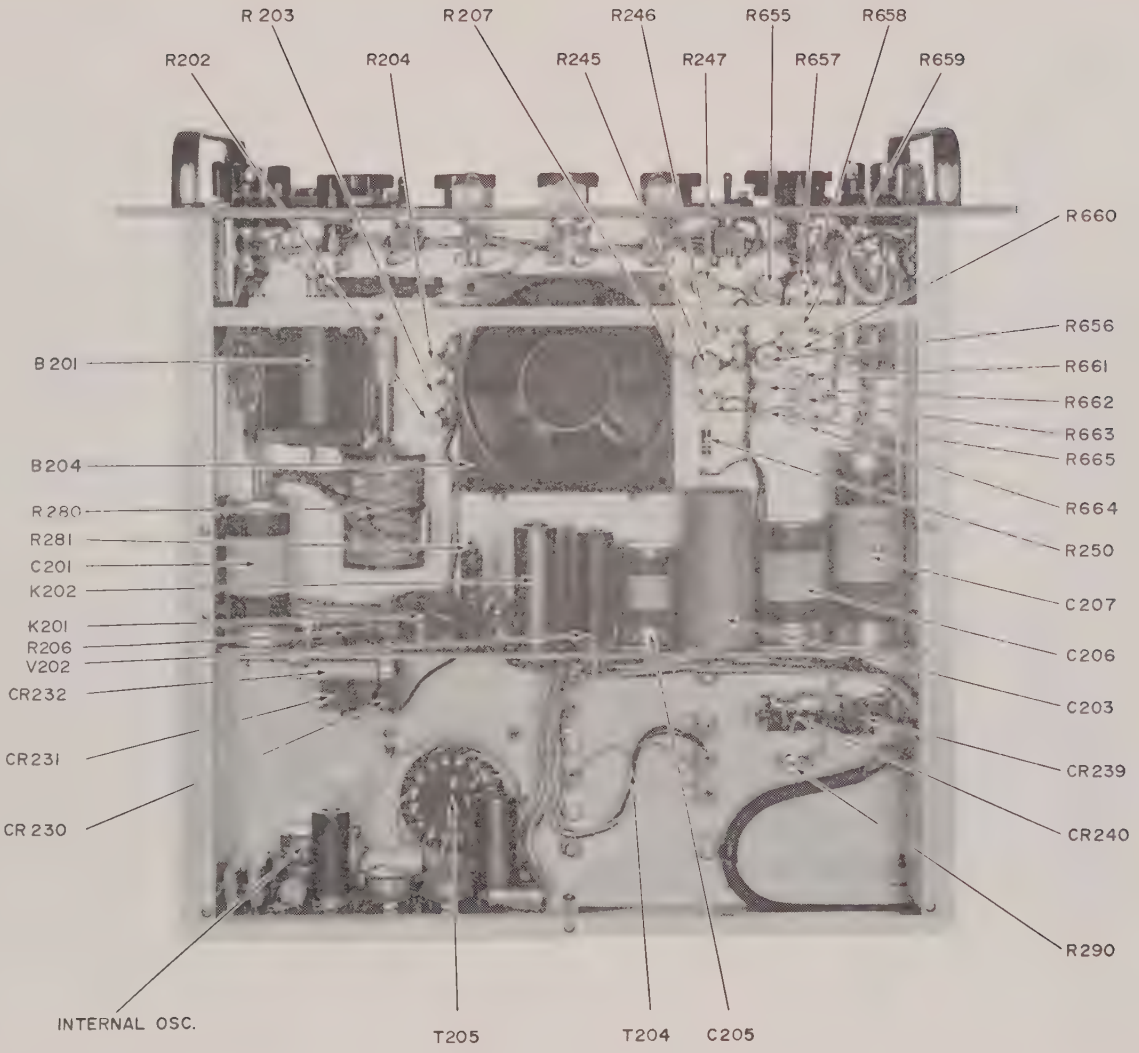
(Pwr Amp 6.9)



(150 V Reg 6.10)



(250 V Reg. 6.1)



Bottom View 6.12

REPLACEMENT OF COMPONENTS:

Holt Instrument Laboratories will supply replacement components at current net prices. Most of the components are standard electronic and radio parts however, and we suggest you get them from your local supplier if possible. Be sure to consult the parts list for manufacturer and for value and tolerances required.

We specially select or modify the value of some of the components whose values must fall within prescribed limits. These selected or modified components will have standard RETMA color-code markings showing the values and tolerances of the stock they were selected from, but will not in general be replaceable from suppliers stocks.

PARTS - ORDERING INFORMATION:

You will find a serial number on the frontispiece of this instruction manual. This is the serial number of the instrument the manual was prepared for. Be certain that the serial number in the instruction manual matches the number of the instrument when you order parts from it.

A Holt Instrument Laboratories instruction manual may contain hand-made changes to diagrams, parts lists and sometimes text. These changes are in general only appropriate to the instrument the manual was prepared for, the instrument whose serial number appears on the manual frontispiece. The hand-made changes show changes to the instrument that have been made after the printing of the manual.

Some of the instrument changes are made during the factory test procedure. Where performance warrants it, technicians hand-tailor circuits. Other changes are made to include the latest

improvements as they are developed in our engineering department, to utilize improved components that have become available. In any event, all changes are made for your benefit. When ordering parts be sure in include the serial number and part number. Also, the Holt Instrument Laboratory stock number where possible.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corporation	New Bedford, Mass
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Company	New York, N.Y.
D	Arrow, Hart, & Hegeman	Hartford, Conn.
E	Arco-Elmenco	New York 13, N.Y.
F	American Spring & Wire Co.	Chicago, Ill
G	Bowmar Instrument Lab	Fort Wayne, Ind.
H	Centralab	Milwaukee 1, Wis.
HIL	Holt Instrument Labs	Oconto, Wis.
I	Chicago Standard Trans Corp	Chicago, Ill
J	Cornish Wire Co.	New York 7, N.Y.
K	Daven	Livingston, N.J.
L	Daystrom Pacific	Los Angeles, Calif.
M	Drake	Chicago, Ill
N	Electro Instruments, Inc.	San Diego, Calif.
O	Eldema Corp.	El Monte, Calif.
P	Electron Prod.	Pasadena, Calif.
Q	Good-All Electric Mfg. Co.	Ogallala, Nebr.
R	General Electric	Schenectady, N.Y.
S	General Radio	West Concord, Mass.
T	Guardian Electric	Chicago, Ill.
U	Hoffman Semi-Conductor	Evanston, Ill.
V	Hughes Semi-Conductor Corp.	Oceanside, Calif.
W	International Rectifier Corp.	El Segundo, Calif.
X	International Resistance Co.	Philadelphia 8, Pa.
Y	James Vibrapowr	Chicago, Ill
Z	Any brand tube meeting RETMA characteristics	
AA	Bunting Brass & Bronze Co.	Toledo 1, Ohio
BB	Little Fuse	Des Plaines, Ill.
CC	Mallory & Co.	Indianapolis, Ind.
DD	Northern Engineering Lab	Burlington, Wis.
EE	Oak Mfg. Co.	Chicago, Ill.
FF	Ohmite	Skokie, Ill
GG	Raytheon	Newton, Mass.
HH	Rotron Mfg. Co.	Woodstock, N.Y.
II	Sage Electronics	East Rochester, N.Y.
JJ	Switchcraft	Chicago 30, Ill.
KK	Spectrol Electronics	San Gabriel, Calif.
LL	SNC Transformer Corp.	Oshkosh, Wis.
MM	Southern Electronics	Burbank, Calif.
NN	Sprague	North Adams, Mass.
OO	Sarkes Tarzian	Bloomington, Ill.
PP	Stancor	Chicago, Ill.
QQ	Topaz Products, Inc.	San Diego, Calif.
RR	Weston	Newark, N.J.
SS	Beckman Instruments	Fullerton, Calif.
TT	Nucleonics Products Corp.	Los Angeles, Calif.
UU	Miller, J. W.	Los Angeles, Calif.
VV	Triad Transformer Co.	Venice, Calif.
WW	Radio Condenser Co.	Camden, N.J.
XX	Texas Instrument	Dallas, Texas

CODE LETTER	MANUFACTURER	ADDRESS
YY	Pacific Semiconductor	Culver City, Calif.
ZZ	Leeds & Northrup Co.	Philadelphia, Pa.
AB	Vacuum Products	Mt. Vernon, N.Y.
AC	Corning-Glass Works	Bradford, Pa.
AD	Diehl Mfg. Co.	Sommerville, N.J.
AE	Astron Corp.	East Newark, N.J.
AF	Chicago Condenser Corp.	Chicago, Ill.
AG	Elco Sales Co.	Philadelphia, Pa.
AH	James Millen Mfg. Co.	Malden, Mass.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
B 201	Motor, Servo 2 Phase	12402-002	AD FPE-25-79-2
B 204	Fan, Venturi, 115 VAC 60cps, Single Phase	12401-001	HH Venturi
C 101	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW, Part of Z 101	10515-503	NN 4 TM-S5
C 102	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW, Part of Z 101	10515-503	NN 4 TM-S5
C 103	Capacitor, Fixed, Metalyte 1 MFD, 200 VDCW, Part of Z 101	10543-105	AE ML-2
C 104	Capacitor, Fixed, Silvered Mica 5600 MMFD, 500 VDCW, ± 2%, Part of Z103	10546-562	E CM-30
C 105	Capacitor, Fixed, Metallized, Paper .1 MFD, 200 VDCW	10583-104	A P-123 Z
C 106	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW	10515-503	NN 4 TM-S5
C 107	Capacitor, Fixed, Triple Section Electrolytic 20-20-40 MFD, 250 VDCW	10581-806	CC FP 320
C 108	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW	10515-503	NN 4 TM-S5
C 109	Capacitor, Fixed, Silvered Mica 5600 MMFD, 500 VDCW, ± 2%, Part of Z103	10546-562	E CM-30
C 110	Capacitor, Fixed, Silvered Mica 5600 MMFD, 500 VDCW, ± 2%, Part of Z103	10546-562	E CM-30
C 111	Capacitor, Fixed, Silvered Mica 5600 MMFD, 500 VDCW, ± 2%, Part of Z103	10546-562	E CM-30
C 112	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	10508-103	H DD6-103
C 113	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW	10515-503	NN 4 TM-S5
C 114	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW	10515-503	NN 4 TM-S5
C 115	Capacitor, Fixed, Electrolytic 110 MFD, 3 VDCW	10571-117	NN TE-1060
C 116	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	10508-103	H DD6-103

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
C 201	Capacitor, Fixed, Electrolytic Dual Section, 40-40 MFD, 450 VDCW	10501-406	CC FP-238
C 202	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW	10515-503	NN 4 TM-S5
C 203	Capacitor, Fixed, Electrolytic Dual Section, 40-40 MFD, 450 VDCW	10501-406	CC FP-238
C 204	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	10508-103	H DD6-103
C 205	Capacitor, Fixed, Electrolytic 50 MFD, 150 VDCW	10521-506	CC FP 115
C 206	Capacitor, Fixed, Electrolytic 2000 MFD, 15 VDCW	10591-208	CC WP-041
C 207	Capacitor, Fixed, Electrolytic, Dual Section, 80-50 MFD, 475 VDCW	10601-137	CC FP 266
C 208	Capacitor, Fixed, Dur-Mica 100 MMFD, 500 VDCW, ± 10%	10516-101	E DM-15
C 210	Capacitor, Fixed, Dur-Mica 15 MMFD, 500 VDCW, ± 10%	10516-150	E DM-15
C 211	Capacitor, Fixed, Dur-Mica 1200 MMFD, 500 VDCW, ± 10%	10526-122	E DM-19
C 213	Capacitor, Fixed, Dur-Mica 100 MMFD, 500 VDCW, ± 10%	10516-101	E DM-15
C 214	Capacitor, Fixed, Dur-Mica 820 MMFD, 500 VDCW, ± 10%	10526-821	E DM-19
C 215	Capacitor, Fixed, Dur-Mica 15 MMFD, 500 VDCW, ± 10%	10516-150	E DM-15
C 216	Capacitor, Fixed, Dur-Mica 1200 MMFD, 500 VDCW, ± 10%	10526-122	E DM-19
C 217	Capacitor, Fixed, Dur-Mica 100 MMFD, 500 VDCW, ± 10%	10516-101	E DM-15
C 218	Capacitor, Fixed, Dur-Mica 820 MMFD, 500 VDCW, ± 10%	10526-821	E DM-19

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
C 219	Capacitor, Fixed, Mylar Paper .2 MFD, 400 VDCW	10565-204	Q 600-UE
C 220	Capacitor, Fixed, Electrolytic 15 MFD, 25 VDCW	10611-156	NN TE 1205
C 260	Capacitor, Fixed, Electrolytic 15 MFD, 25 VDCW	10611-156	NN TE 1205
C 261	Capacitor, Fixed, Silver-Mica 5600 MMFD, 500 VDCW, ± 10%	10546-562	E CM-30
C 262	Capacitor, Fixed, Silver-Mica 5600 MMFD, 500 VDCW, ± 10%	10546-562	E CM-30
C 263	Capacitor, Fixed, Metallized Paper 2.5 MFD, 400 VDCW	10573-255	P M4-255
C 265	Capacitor, Fixed, Metallized Paper .22 MFD, 400 VDCW	10503-224	A P123Z
C 266	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	10508-103	H DD6-103
C 267	Capacitor, Fixed, Dur-Mica 75 MMFD, 500 VDCW, ± 10%	10516-750	E DM-15
C 268	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDCW	10515-503	NN 4 TM-S5
C 269	Capacitor, Fixed, Metallized Paper .22 MFD, 400 VDCW	10503-224	A P-123Z
C 270	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	10508-103	H DD6-103
C 302	Capacitor, Fixed, Dur-Mica 1500 MMFD, 500 VDCW, ± 10%	10526-152	E DM-19
C 303	Capacitor, Fixed, Dur-Mica 910 MMFD, 500 VDCW, ± 10%	10526-911	E DM-19
C 304	Capacitor, Fixed, Metallized Paper .22 MFD, 200 VDCW	10583-224	A P123Z
C 305	Capacitor, Fixed, Mylar Paper .01 MFD, 400 VDCW, ± 10%	10515-103	NN 4 TM-S1
C 306	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	10508-103	H DD6-103
C 307	Capacitor, Trimmer, Tubular 1 - 7.5 MMFD, 600 VDCW	10528-000	H 829-7

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
C 309	Capacitor, Fixed, Dur-Mica 1200 MMFD, 500 VDCW, ± 10%	10526-122	E DM-19
C 310	Capacitor, Fixed, Dur-Mica 910 MMFD, 500 VDCW, ± 10%	10526-911	E DM-19
C 311	Capacitor, Fixed, Metallized Paper Factory Selected Value		P
C 312	Capacitor, Fixed, Mylar Paper .01 MFD, 400 VDCW, ± 10%	10515-103	NN 4 TM-S1
C 317	Capacitor, Fixed, Dur-Mica 430 MMFD, 500 VDCW, ± 10%	10516-431	E DM-15
C 318	Capacitor, Fixed, Mylar 5 MFD, 200 VDCW, ± 10%	10575-505	MM MY-5-10-200E
C 321	Capacitor, Fixed, Ceramic Factory Selected Value		H TCZ
C 401	Capacitor, Fixed, Mylar .22 MFD, 100 VDCW, ± 1%	10585-224	Q 663 UW
C 402	Capacitor, Fixed, Mylar .275 MFD, 50 VDCW, ± 1%	10605-274	AF 2594
C 403	Capacitor, Fixed, Mylar .043 MFD, 100 VDCW, ± 1%	10585-433	Q 663 UW
C 404	Capacitor, Fixed, Mylar .35 MFD, 50 VDCW, ± 1%	10605-354	AF 2593
C 405	Capacitor, Fixed, Mylar .35 MFD, 50 VDCW, ± 1%	10605-354	AF 2593
C 406	Capacitor, Fixed, Mylar .033 MFD, 200 VDCW, ± 1%	10635-333	Q 663 UW
C 407	Capacitor, Fixed, Mylar .275 MFD, 50 VDCW, ± 1%	10605-274	AF 2594
C 408	Capacitor, Fixed, Mylar .22 MFD, 100 VDCW, ± 1%	10585-224	Q 663-UW
C409	Capacitor, Fixed, Metallized Paper .5 MFD, 200 VDC, ± 20%	10513-504	P
C 601	Capacitor, Fixed, Dur-Mica 360 MMFD, 300 VDCW, ± 10%	10536-361	E DM-15
C 602	Capacitor, Fixed, Dur-Mica 620 MMFD, 500 VDCW, ± 10%	10526-621	E DM-19
C 603	Capacitor, Fixed, Dur-Mica 620 MMFD, 500 VDCW, ± 10%	10526-621	E DM-19

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
C 604	Capacitor, Fixed, Dur-Mica Factory selected value		E DM-15
C 703	Capacitor, Fixed, Metallized Paper .22 MFD, 400 VDCW	10503-224	A P 123Z
C 704	Capacitor, Fixed, Metallized Paper .22 MFD, 400 VDCW	10503-224	A P 123Z
C 705	Capacitor, Fixed, Metallized Paper .22 MFD, 400 VDCW	10503-224	A P 123Z
C 706	Capacitor, Fixed, Paper .02 MFD, 600 VDCW	10504-203	CC GEM-612
C 707	Capacitor, Fixed, Paper .02 MFD, 600 VDCW	10504-203	CC GEM-612
C 708	Capacitor, Fixed, Dur-Mica Factory Selected Value		E DM-15
C 709	Capacitor, Fixed, Disc .01 MFD, 600 VDCW	10508-103	H DD6-103
C 710	Capacitor, Fixed, Metallized Paper .1 MFD, 400 VDCW	10563-104	A P 123ZG
C 711	Capacitor, Fixed, Electrolytic 300 MFD, 3 VDCW	10571-307	NN TE-1066
CR 220	Diode, Germanium PIV 84 V	11402-004	TT IN 48
CR 221	Diode, Germanium PIV 84 V	11402-004	TT IN 48
CR 230	Rectifier, Silicon, 750 MA 4ABI, Max. PIV 2000 V	11471-006	00 120 SM
CR 231	Rectifier, Silicon, 250 MA 1ABI, Max. PIV 2000 V	11471-006	00 120 SM
CR 232	Rectifier, Silicon, 425 MA IN 1109, Max. PIV 1200 V	11431-001	00 120 SM
CR 239	Rectifier, Germanium, Double 400 MA, Max. PIV 380 V	11412-006	R IN 1016

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr & Mfr. Designation
CR 240	Rectifier, Germanium, Double 400 MA, Max. PIV 380 V	11412-006	R IN 1016
CR 301	Diode, Silicon PIV, 125 V, 4 MA	11411-003	V IN 628
CR 302	Diode, Silicon PIV, 125 V, 4 MA	11411-003	V IN 628
CR 303	Diode, Silicon PIV, 125 V, 4 MA	11411-003	V IN 628
DS 202	Lamp, Neon, Indicating 65-130 VAC	13112-006	M Type 105
DS 203	Lamp, Neon, Indication 65-130 VAC	13112-006	M Type 105
DS 204	Lamp, Neon, Indicating 65-130 VAC	13112-006	M Type 105
DS 205	Lamp, Neon, Miniature, Indicating Clear Lens with 100 K Resistor	13102-006	O Type 1EG3
DS 206	Lamp, Neon, Miniature, Indicating Clear Lens with 100 K Resistor	13102-006	O Type 1EG3
F 201	Fuse, Slo-Blo 3 AG, 2 Amp	13103-202	BB 313002
F 202	Fuse, Slo-Blo 3 AG, 4 Amp	13103-402	BB 313004
G 101	Chopper	51669-001	
J 202	Connector, Receptacle 12 contact	12641-012	AG PCV 2-12-A 3/32-0-T6
J 203	Connector, Receptacle 12 contact	12641-012	AG PCV 2-12-A 3/32-0-T6
K 201	Relay, Medium Power 8 Amp, 115 V, DPDT	12505-002	T IR-1200-G 115
K 202	Relay, Time Delay 30 Second, 115 V, SPST	12501-001	C 115N030T
L 101	Choke, 3.5 Henry	11823-355	QQ 00107

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
L 301	Choke, RF 750 Microhenry, 250 MA	11812-751	AH 34300
L 401	Choke, Audio 720 Ω DC	11833	QQ 71018
L 402	Choke, Audio 5500 Ω DC	11863	LL P 3751
L 403	Choke, Audio 2375 Ω DC	11843	QQ 7812
L 404	Choke, Audio 2430 Ω DC	11853	QQ 7813
L 405	Choke, Audio 720 Ω DC	11833	QQ 71018
M 203	**Meter** **0-100 ua**	12300	R 8DW91A344AE2
P 201	Line Cord with Molded Cap 3 Conductor	12612-003	J 3532
P 202	Connector, Plug 12 contact	12642-012	AG CS-12-R-200
P 203	Connector, Plug 12 contact	12642-012	AG CS-12-R-200
R 101	Resistor, Fixed, Composition 100 K Ω, ½ W, ± 10%, Part of Z101	10001-104	FF RC-20
R 102	Resistor, Fixed, Composition 100 K Ω, ½ W, ± 10%, Part of Z101	10001-104	FF RC-20
R 103	Resistor, Fixed, Wire Wound 2677 Ω, ± .05%, Part of Z 101	10007-004	N 286
R 104	Resistor, Variable, Wire Wound 200 Ω, ± 5% Part of Z101	10085-201	L 301-60
R 105	Resistor, Fixed, Wire Wound 3333 Ω, ± .05%, Part of Z 101	10007-005	N 286
R 106	Resistor, Fixed, Wire Wound 15 K Ω, 5 W, ± 1%	10057-153	II SS-5W
R 107	Resistor, Fixed, Composition 1 MEG Ω, ½ W, ± 10% *	10001-105	FF RC-20

* Some instruments have 5% Resistors due to quantity purchases.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 109	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10% *	10001-474	FF RC-20
R 110	Resistor, Fixed, Composition 22 K Ω, ½ Watt, ± 10%	10001-223	FF RC-20
R 111	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 112	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10% *	10001-474	FF RC-20
R 113	Resistor, Fixed, Composition 22 K Ω, ½ Watt, ± 10%	10001-223	FF RC-20
R 114	Resistor, Fixed, Composition 470 K Ω, Part of Z 103, ½ Watt, ± 10%*	10001-474	FF RC-20
R 115	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10%* Part of Z 103	10001-474	FF RC-20
R 116	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10%, Part of Z103*	10001-474	FF RC-20
R 117	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10%, Part of Z103*	10001-474	FF RC-20
R 118	Resistor, Variable, Composition 1 Meg Ω, 2 Watt, ± 10% *	10005-105	FF CLU 1052
R 119	Resistor, Fixed, Composition 22 K Ω, 1 Watt, ± 10%	10031-223	FF RC-32
R 120	Resistor, Fixed, Composition 3.9 K Ω, ½ Watt, ± 10%	10001-392	FF RC-20
R 121	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10% *	10001-474	FF RC-20
R 122	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10% *	10001-474	FF RC-20
R 123	Resistor, Fixed, Composition 68 K Ω, ½ Watt, ± 10%	10001-683	FF RC-20
R 124	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10% *	10001-474	FF RC-20
R 125	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10% *	10001-474	FF RC-20
R 126	Resistor, Fixed, Composition 220 Ω. 2 Watt, ± 10%	10021-221	FF RC-42

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 127	Resistor, Fixed, Composition 3.3 K Ω, ½ Watt, ± 10%, Part of Z101	10001-332	FF RC-20
R 128	Resistor, Fixed, Composition Factory selected value		FF RC-20
R 129	Resistor, Fixed Composition 2.2 K Ω, ½ Watt, ± 10%	10001-222	FF RC-20
R 201	Resistor, Fixed, Wire Wound 400 Ω, 20 Watt, ± 5 %	10042-401	FF Brown Devil
R 202	Resistor, Fixed, Wire Wound 400 Ω, 20 Watt, ± 5 %	10042-401	FF Brown Devil
R 203	Resistor, Fixed, Wire Wound 50 K Ω, 10 Watt, ± 5 %	10012-503	FF Brown Devil
R 204	Resistor, Fixed, Wire Wound 30 K Ω, 10 Watt, ± 5 %	10012-303	FF Brown Devil
R 205	Resistor, Fixed, Composition 100 K Ω, ½ Watt ± 10%	10001-104	FF RC-20
R 206	Resistor, Fixed, Wire Wound 7.5 K, 5 Watt, ± 5%	10002-752	FF RC-42
R 207	Resistor, Fixed, Wire Wound 12.5 KΩ, 10 Watt, ± 5%	10012-12A	FF Brown Devil
R 208	Resistor, Fixed, Composition 33 K Ω, ½ Watt, ± 10%	10001-333	FF RC-20
R 209	Resistor, Fixed, Composition 1 K Ω, ½ Watt, ± 10%	10001-102	FF RC-20
R 210	Resistor, Fixed, Composition 1 K Ω, ½ Watt, ± 10%	10001-102	FF RC-20
R 211	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 212	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 213	Resistor, Fixed, Composition 1 Meg, Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 214	Resistor, Fixed, Composition 10 K Ω, ½ Watt, ± 10%	10001-103	FF RC-20
R 215	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 216	Resistor, Fixed, Composition 10 K Ω, ½ Watt, ± 10%	10001-103	FF RC-20
R 217	Resistor, Fixed, Composition 47 K Ω, ½ Watt, ± 10%	10001-473	FF RC-20
R 218	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10 % *	10001-105	FF RC-20
R 219	Resistor, Fixed, Composition 100 K Ω, ½ Watt, ± 10 %	10001-104	FF RC-20
R 220	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 221	Resistor, Fixed, Composition 180 K Ω, ½ Watt, ± 10%	10001-184	FF RC-20
R 222	Resistor, Fixed, Deposited Carbon 130 K Ω, ½ Watt, ± 1%	10003-134	X DCC
R 223	Resistor, Fixed, Composition 82 K Ω, ½ Watt, ± 10%	10001-823	FF RC-20
R 224	Resistor, Fixed, Deposited Carbon 100 K Ω, ½ Watt, ± 1%	10003-104	X DCC
R 225	Resistor, Fixed, Composition 33 K Ω, 1 Watt, ± 10%	10031-333	FF RC-32
R 226	Resistor, Fixed, Composition 330 K Ω, ½ Watt, ± 10 %	10001-334	FF RC-20
R 228	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 229	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 230	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 231	Resistor, Fixed, Composition 10 K Ω, ½ Watt, ± 10%	10001-103	FF RC-20
R 232	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 233	Resistor, Fixed, Composition 10 K Ω, ½ Watt, ± 10%	10001-103	FF RC-20
R 234	Resistor, Fixed, Composition 47 K Ω, ½ Watt, ± 10%	10001-473	FF RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 235	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 236	Resistor, Fixed, Composition 100 K Ω, ½ Watt, ± 10%	10001-104	FF RC-20
R 237	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 238	Resistor, Fixed, Composition 180 K Ω, ½ Watt, ± 10%	10001-184	FF RC-20
R 239	Resistor, Fixed, Deposited Carbon 75 K Ω, ½ Watt, ± 1%	10003-753	X DCC
R 240	Resistor, Fixed, Composition 82 K Ω, ½ Watt, ± 10%	10001-823	FF RC-20
R 241	Resistor, Fixed, Deposited Carbon 100 K Ω, ½ Watt, ± 1%	10003-104	X DCC
R 242	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 10% *	10001-474	FF RC-20
R 245	Resistor, Fixed, Wire Wound 75 Ω, 25 Watt, ± 5%	10122-750	FF Lug Type
R 246	Resistor, Fixed, Wire Wound 100 Ω, 20 Watt, ± 5%	10042-101	FF Brown Devil
R 247	Resistor, Fixed, Wire Wound 1.5 K Ω, 25 Watt, ± 5%	10122-152	FF Lug Type
R 249	Resistor, Fixed, Composition Factory selected Value, 1 Watt, ± 10%		FF RC-32
R 250	Resistor, Fixed, Composition 390 K Ω, 1 Watt, ± 10%	10031-394	FF RC-32
R 260	Resistor, Fixed, Composition 2200 Ω, ½ Watt, ± 10%	10001-222	FF RC-20
R 261	Resistor, Fixed, Composition 2200 Ω, ½ Watt, ± 10%	10001-222	FF RC-20
R 262	Resistor, Variable, Dual, Composition 25 K Ω/25 K Ω, 2 Watt, ± 10%	10105-253	FF CCU 2531
R 263	Resistor, Fixed, Composition 27 KΩ, 1/2 Watt, ± 10%	10001-273	FF RC-20
R 264	Resistor, Fixed, Deposited Carbon 475 KΩ, 1/2 Watt, ± 1%	10003-47E	X DCC

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 265	Resistor, Fixed, Deposited Carbon 475 KΩ, 1/2 Watt, ± 1%	10003-47E	X DCC
R 266	Resistor, Fixed, Composition 27 KΩ, 1/2 Watt, ± 10%	10001-273	FF RC-20
R 267	Resistor, Variable, Composition 500 Ω, 2 Watt, ± 10%	10005-501	FF CLU 5011
R 268	Resistor, Fixed, Composition 100 K Ω, ½ Watt, ± 10%	10001-104	FF RC-20
R 269	Resistor, Fixed, Composition 1200 Ω, ½ Watt, ± 10%	10001-122	FF RC-20
R 270	Resistor, Fixed, Composition 1500 Ω, ½ Watt, ± 10%	10001-152	FF RC-20
R 271	Resistor, Variable, Composition 1000 Ω, 2 Watt, ± 10%	10005-102	FF CLU 1021
R 272	Resistor, Fixed, Composition 1200 Ω, ½ Watt, ± 10%	10001-122	FF RC-20
R 273	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 274	Resistor, Fixed, Composition 1 K Ω, ½ Watt, ± 10%	10001-102	FF RC-20
R 275	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 276	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 277	Resistor, Fixed, Composition 1000 Ω, ½ Watt, ± 10%	10001-102	FF RC-20
R 278	Resistor, Fixed, Composition 27 K Ω, ½ Watt, ± 10%	10001-273	FF RC-20
R 279	Resistor, Fixed, Composition 1200 Ω. ½ Watt, ± 10%	10001-122	FF RC-20
R 280	Resistor, Variable, Dual, Wire Wound 1 K Ω/10 K Ω, ± 3%	52665 /	
R 281	Resistor, Fixed, Composition 270 K Ω, ½ Watt, ± 10%	10001-274	FF RC-20
R 282	Resistor, Fixed, Composition 330 Ω, ½ Watt, ± 10%	10001-331	FF RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 283	Resistor, Fixed, Composition 820 Ω, ½ Watt, ± 10%	10001-821	FF RC-20
R 284	Resistor, Fixed, Composition 1000 Ω, ½ Watt, ± 10%	10001-102	FF RC-20
R 285	Resistor, Fixed, Composition 1000 Ω, ½ Watt, ± 10%	10001-102	FF RC-20
R 286	Resistor, Fixed, Composition 220 K Ω, ½ Watt, ± 10%	10001-224	FF RC-20
R 287	Resistor, Fixed, Composition 39 K Ω, ½ Watt, ± 10%	10001-393	FF RC-20
R 288	Resistor, Fixed, Composition 68 K Ω, 1 Watt, ± 10%	10031-683	FF RC-32
R 289	Resistor, Fixed, Composition Factory selected Value		FF RC-20
R 290	Resistor, Fixed, Wire Wound 3 Ω, 5 Watt, ± 5 %	10002-030	FF Brown Devil
R 301	Resistor, Fixed, Wire Wound 10 K Ω, ± .05%, Mica Card	10017-103	S 602-305-2
R 302	Resistor, Fixed, Wire Wound 10 K Ω, ± .05%, Mica Card	10017-103	S 602-305-2
R 303	Resistor, Fixed, Composition 6.8 K Ω, 2 Watt, ± 10%	10021-682	FF RC-42
R 304	Resistor, Fixed, Composition 1.8 K Ω, ½ Watt, ± 10%	10001-182	FF RC-20
R 305	Resistor, Fixed, Composition 680 Ω, ½ Watt, ± 10%	10001-681	FF RC-20
R 306	Resistor, Fixed, Deposited Carbon 1 Meg Ω, ½ Watt, ± 1%	10003-105	X DCC
R 307	Resistor, Fixed, Deposited Carbon Factory selected value, ½ Watt, ± 1%		X DCC
R 308	Resistor, Fixed, Deposited Carbon 4.32 Meg Ω, 1/2 Watt, ± 1%	10003-43F	X DCC
R 309	Resistor, Fixed, Composition 6.8 K Ω, 2 Watt, ± 10%	10021-682	FF RC-42
R 310	Resistor, Fixed, Composition 1.8 K Ω, ½ Watt, ± 10%	10001-182	FF RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 311	Resistor, Fixed, Composition 820 Ω, ½ Watt, ± 10%	10001-821	FF RC-20
R 312	Resistor, Fixed, Composition 3.9 Meg Ω, ½ Watt, ± 10%	10001-395	FF RC-20
R 313	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 314	Resistor, Fixed, Deposited Carbon 1 Meg Ω, ½ Watt, ± 1%	10003-105	X DCC
R 315	Resistor, Fixed, Composition 1.2 K Ω, ½ Watt, ± 10%	10001-122	FF RC-20
R 316	Resistor, Fixed, Deposited Carbon 4.75 Meg Ω, 1/2 Watt, ± 1%	10003-47F	X DCC
R 318	Resistor, Fixed, Wire Wound 10 K Ω, 10 Watt, ± 5%	10012-103	FF Brown Devil
R 319	Resistor, Fixed, Deposited Carbon 130 K Ω, ½ Watt, ± 1%	10003-134	X DCC
R 320	Resistor, Fixed, Wire Wound 10 K Ω, ± .05%, Mica Card	10017-103	S 602-305-2
R 321	Resistor, Fixed, Wire Wound 10 K Ω, ± .05%, Mica Card	10017-103	S 602-305-2
R 322	Resistor, Fixed, Wire Wound 435 Ω, ± .05%, Jelly Bean	10007-006	N 286
R 323	Resistor, Fixed, Deposited Carbon Factory selected Value, ½ Watt, ± 1%		X DCC
R 324	Resistor, Fixed, Wire Wound 305.0 Ω, ± .05%, Mica Card	10027-001	S 510-390
R 325	Resistor, Variable, Wire Wound 10 Ω, ± 5%	10085-100	L 301-60
R 326	Resistor, Variable, Composition 100 Ω, 2 Watt, ± 10%	10005-101	FF CLU 1011
R 329	Resistor, Fixed, Wire Wound 10 Ω, .33 Watt, ± 1%	10037-100	K 1250
R 331	Resistor, Fixed, Composition 470 K, ½ Watt, ± 10% *	10001-474	FF RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr & Mfr. Designation
R 401	Resistor, Fixed, Wire Wound 100 K Ω, ± .05%, Round Bobbin	10047-104	N 185
R 402	Resistor, Fixed, Wire Wound 50 K Ω, ± .05%, Round Bobbin	10047-503	N 185
R 601	Resistor, Fixed, Wire Wound 30 K Ω, ± .05%, Mica-Card	10027-303	S 510-390
R 602	Resistor, Fixed, Wire Wound 30 K Ω, ± .05%, Mica Card	10027-303	S 510-390
R 603	Resistor, Fixed, Wire Wound 30K Ω, ± .05%, Mica Card	10027-303	S 510-390
R 604	Resistor, Fixed, Wire Wound 30K Ω, ± .05%, Mica Card	10027-303	S 510-390
R 605	Resistor, Fixed, Wire Wound 30K Ω, ± .05%, Mica Card	10027-303	S 510-390
R 606	Resistor, Fixed, Wire Wound 30K Ω, ±.05%, Mica Card	10027-303	S 510-390
R 607	Resistor, Fixed, Wire Wound 30K Ω, ± .05%, Mica Card	10027-303	S 510-390
R 608	Resistor, Fixed, Wire Wound 30K Ω, ± .05%, Mica Card	10027-303	S 510-390
R 609	Resistor, Fixed, Wire Wound 29.7K Ω, ± .05%, Mica Card	10027-002	S 510-390
R 611	Resistor, Fixed, Wire Wound 3K Ω, ± .05%, Mica Card	10027-302	S 510-390
R 612	Resistor, Fixed, Wire Wound 3K Ω, ± .05%, Mica Card	10027-302	S 510-390
R 613	Resistor, Fixed, Wire Wound 3K Ω, ± .05%, Mica Card	10027-302	S 510-390
R 614	Resistor, Fixed, Wire Wound 3K Ohms, ± .05%, Mica Card	10027-302	S 510-390
R 615	Resistor, Fixed, Wire Wound 3K Ω, ± .05%, Mica Card	10027-302	S 510-390
R 616	Resistor, Fixed, Wire Wound 3K Ω, ± .05%, Mica Card	10027-302	S 510-390

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 617	Resistor, Fixed, Wire Wound 3K Ω, ± .05%, Mica Card	10027-302	S 510-390
R 618	Resistor, Fixed, Wire Wound 3K Ω, ± .05%, Mica Card	10027-302	S 510-390
R 619	Resistor, Fixed, Wire Wound 2.7K Ω, ± .05%, Mica Card	10027-272	S 510-390
R 624	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 625	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 626	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 627	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 628	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 629	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 630	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 631	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 632	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 633	Resistor, Fixed, Wire Wound 300 Ω, ± .05%, Mica Card	10027-301	S 510-390
R 635	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 636	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 637	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 638	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 639	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 640	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 641	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 642	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 643	Resistor, Fixed, Wire Wound 30 Ω, ± .05%, Jelly Bean	10007-300	N 286
R 644	Resistor, Variable, Wire Wound 30 Ω, -1+3%	10046-300	KK 130-275
R 655	Resistor, Fixed, Wire Wound 2250 Ω, 25 Watt, ± 10%	10112-001	FF 2K-48-F
R 656	Resistor, Fixed, Wire Wound 2250 Ω , 25 Watt, ± 10%	10112-001	FF 2K-48-F
R 657	Resistor, Fixed, Wire Wound 350 Ω, 5 Watt, ± 10%	10002-351	FF Brown Devil
R 658	Resistor, Fixed, Wire Wound 400 Ω, 5 Watt, ± 10%	10002-401	FF Brown Devil
R 659	Resistor, Fixed, Wire Wound 500 Ω, 5 Watt, ± 10%	10002-501	FF Brown Devil
R 660	Resistor, Fixed, Wire Wound 750 Ω, 5 Watt, ± 10%	10002-751	FF Brown Devil
R 661	Resistor, Fixed, Wire Wound 1K Ω, 5 Watt, ± 10%	10002-102	FF Brown Devil
R 662	Resistor, Fixed, Wire Wound 1.5K Ω, 5 Watt, ± 10%	10002-152	FF Brown Devil
R 663	Resistor, Fixed, Wire Wound 2.5K Ω, 5 Watt, ± 10%	10002-252	FF Brown Devil
R 664	Resistor, Fixed, Wire Wound 5K Ω, 5 Watt, ± 10%	10002-502	FF Brown Devil
R 665	Resistor, Fixed, Wire Wound 15K Ω, 5 Watt, ± 10%	10002-153	FF Brown Devil
R 666	Resistor, Fixed, Deposited Carbon 30.1 KΩ, 1/2 Watt, ± 1%	10003-30G	X DCC

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 667	Resistor, Fixed, Deposited Carbon 47.5 KΩ, 1/2 Watt, ± 1%	10003-47D	X DCC
R 668	Resistor, Fixed, Deposited Carbon 22.1 KΩ, 1/2 Watt, ± 1%	10003-22G	X DCC
R 669	Resistor, Fixed, Composition 4.7K Ω, ½ Watt, ± 10%	10001-472	FF RC-20
R 670	Resistor, Fixed, Composition 4.7 K Ω, ½ Watt, ± 10%	10001-472	FF RC-20
R 671	Resistor, Fixed, Composition 10 K Ω, ½ Watt, ± 10%	10001-103	FF RC-20
R 672	Resistor, Fixed, Composition 10 K Ω, ½ Watt, ± 10%	10001-103	FF RC-20
R 673	Resistor, Fixed, Composition 10 K Ω, ½ Watt , ± 10%	10001-103	FF RC-20
R 674	Resistor, Fixed, Composition 39 K Ω, ½ Watt, ± 10%	10001-393	FF RC-20
R 675	Resistor, Fixed, Composition 39 K Ω, ½ Watt, ± 10%	10001-393	FF RC-20
R 676	Resistor, Fixed, Composition 100 K Ω, ½ Watt, ± 10%	10001-104	FF RC-20
R 677	Resistor, Fixed, Composition 18 K Ω, ½ Watt, ± 5%	10011-183	FF RC-20
R 678	Resistor, Fixed, Composition 18 K Ω, ½ Watt, ± 5%	10011-183	FF RC-20
R 679	Resistor, Fixed, Composition 18 K Ω, ½ Watt, ± 5%	10011-183	FF RC-20
R 680	Resistor, Fixed, Composition 18 K Ω, ½ Watt, ± 5%	10011-183	FF RC-20
R 681	Resistor, Fixed, Composition 18 K Ω, ½ Watt, ± 5%	10011-183	FF RC-20
R 702	Resistor, Fixed, Composition 100 K Ω, ½ Watt, ± 10%	10001-104	FF RC-20
R 704	Resistor, Fixed, Composition 10 K Ω, ½ Watt, ± 10%	10001-103	FF RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 705	Resistor, Fixed, Deposited Carbon 150 Ω, ½ Watt, ± 1%	10003-151	X DCC
R 706	Resistor, Fixed, Composition 39 K Ω, ½ Watt, ± 10%	10001-393	FF RC-20
R 707	Resistor, Fixed, Composition 2.2 Meg Ω, ½ Watt, ± 10%	10001-225	FF RC-20
R 708	Resistor, Fixed, Composition 27 K Ω, ½ Watt, ± 10%	10001-273	FF RC-20
R 709	Resistor, Variable, Composition 10 K Ω, 2 Watt, ± 10%	10005-103	FF CLU 1031
R 710	Resistor, Fixed, Composition 22 K Ω, ½ Watt, ± 10%	10001-223	FF RC-20
R 712	Resistor, Fixed, Composition 47 K Ω, 1 Watt, ± 10%	10031-473	FF RC-32
R 713	Resistor, Fixed, Composition 1 Meg Ω. ½ Watt, ± 10% *	10001-105	FF RC-20.
R 714	Resistor, Fixed, Composition 3.9 K Ω, ½ Watt, ± 10%	10001-392	FF RC-20
R 715	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 716	Resistor, Fixed, Composition 47 K Ω, 1 Watt, ± 10%	10031-473	FF RC-32
R 717	Resistor, Fixed, Composition 22 K Ω. ½ Watt, ± 10%	10001-223	FF RC-20
R 718	Resistor, Fixed, Composition 1 Meg Ω. ½ Watt, ± 10% *	10001-105	FF RC-20
R 719	Resistor, Fixed, Composition 100 K Ω, 2 Watt, ± 10%	10021-104	FF RC-42
R 720	Resistor, Fixed, Composition 1 Meg Ω, ½ Watt, ± 10% *	10001-105	FF RC-20
R 721	Resistor, Fixed, Composition 220 K Ω, ½ Watt, ± 10%	10001-224	FF RC-20
R 722	Resistor, Fixed, Composition 220 K Ω, ½ Watt, ± 10%	10001-224	FF RC-20

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
R 724	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 725	Resistor, Fixed, Composition 560 Ω, 2 Watt, ± 10%	10021-561	FF RC-42
R 726	Resistor, Fixed, Composition 100 Ω, ½ Watt. ± 10%	10001-101	FF RC-20
R 729	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 730	Resistor, Fixed, Composition 560 Ω, 2 Watt, ± 10%	10021-561	FF RC-42
R 731	Resistor, Fixed, Composition 100 Ω, ½ Watt, ± 10%	10001-101	FF RC-20
R 733	Resistor, Fixed, Deposited Carbon 27.4 KΩ, 1/2 Watt, ± 1%	10003-270	X DCC
R 734	Resistor, Fixed, Composition 2.7 K Ω, ½ Watt, ± 10%	10001-273	FF RC-20
R 735	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 5%	10011-474	FF RC-20
R 737	Resistor, Fixed, Composition 470 K Ω, ½ Watt, ± 5%	10011-474	FF RC-20
R 738	Resistor, Fixed, Wire Wound 100 Ω, 10 Watt, ± 10%, Center Tap	10060-101	FF 1668
R 739	Resistor, Fixed, Wire Wound 100 Ω, 10 Watt, ± 10% Center Tap	10060-101	FF 1668
R 740	Resistor, Fixed, Composition 1M Ω, ½ Watt, ± 5%	10011-105	FF RC-20
RT 201	Lamp, Incandescent 230 V, 10 Watt	13121-006	R 10S6/10
S 203	Switch, Bat Handle, Toggle SPST, 3 Amp, 250 V	12004-101	D 20994-LH
S 204	Switch, Bat Handle, Toggle DPDT , 3 Amp, 250 V	12014-202	D 81027-CE
S 205	Switch, Lever, Locking DPDT, 120 V, 3 Amps	12003-202	JJ 3006 L

TABLE OF REPLACEABLE PARTS

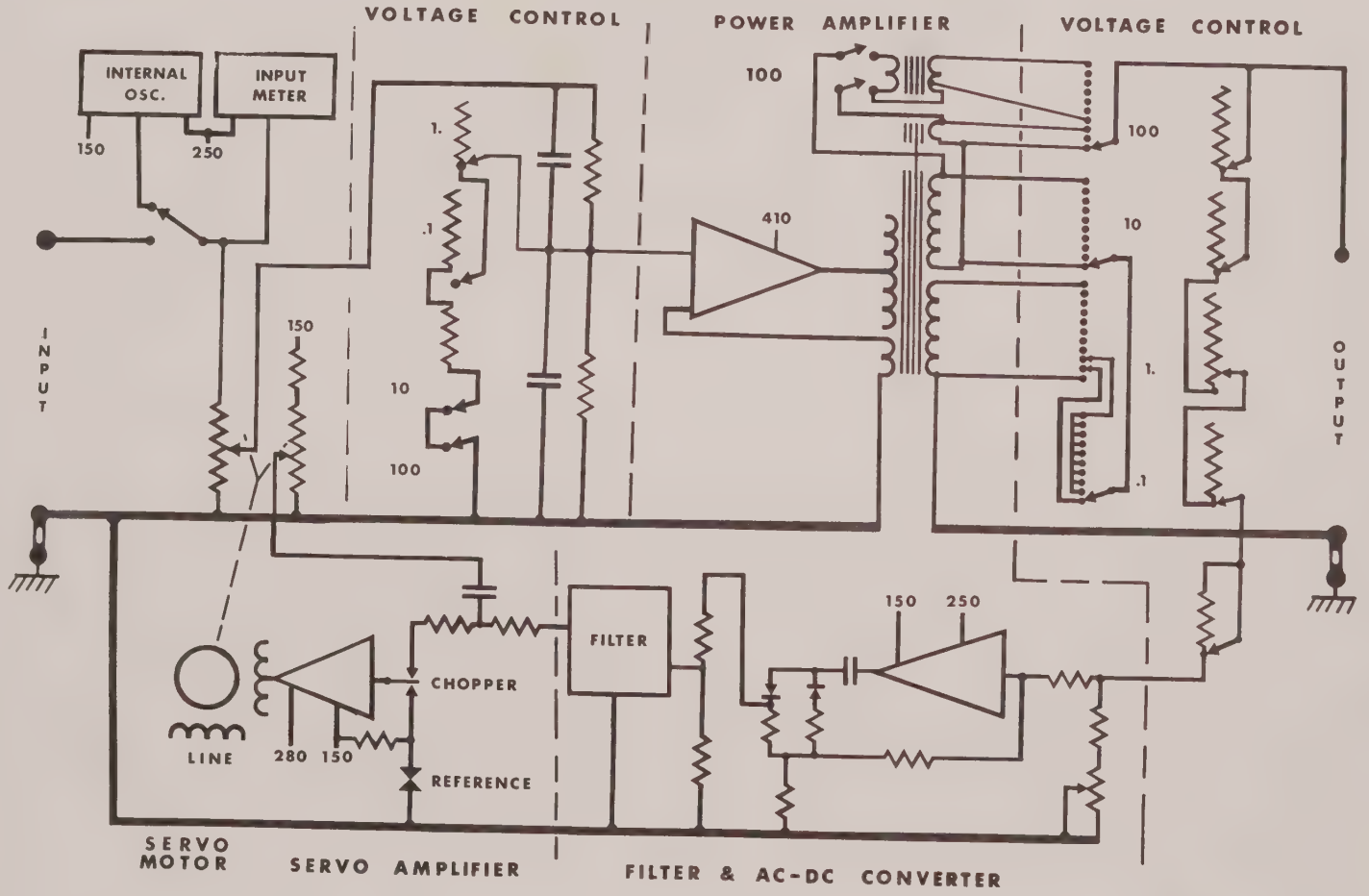
Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
S 600	Decade Switch Assembly 100 Volt Steps	12000	EE 208788-DH4C
S 601	Decade Switch Assembly 10 Volt Steps	12010	EE 208789-DH3C
S 602	Decade Switch Assembly 1 Volt Steps	12020	EE 208790-DH4C
S 603	Decade Switch Assembly 0.1 Volt Steps	12030	EE 208791-DH3C
S 604	Load Watts Switch	51599	
T 101	Transformer, Output	11605	LL P3750
T 204	Transformer, Plate	11641	LL P4200
T 205	Transformer, Filament	11651	LL P4201
T 601	Transformer, Hi-Voltage	11600	QQ 80915
T 701	Transformer, Output	11603	QQ 80916
V 101	Tube, Electron	11005	Z 12AX7
V 102	Tube, Electron	11005	Z 12AX7
V 103	Tube, Electron	11013	Z 6AQ5
V 104	Tube, Electron	11013	Z 6AQ5
V 201	Tube, Electron	11010	GG CK 5783
V 202	Tube, Electron	11001	Z 0B2
V 203	Tube, Electron	11006	Z 12AV7
V 205	Tube, Electron	11005	Z 12AX7

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
V 206	Tube, Electron	11006	Z 12AV7
V 208	Tube, Electron	11005	Z 12 AX7
V 209	Tube, Electron	11006	Z 12 AV7
V 210	Tube, Electron	11002	Z 6AU6
V 211	Tube, Electron	11008	Z 5687
V 212	Tube, Electron	11006	Z 12AV7
V 213	Tube, Electron	11006	Z 12AV7
V 301	Tube, Electron	11014	Z 6136
V 302	Tube, Electron	11002	Z 6AU6
V 303	Tube, Electron	11002	Z 6AU6
V 304	Tube, Electron	11008	Z 5687
V 701	Tube, Electron	11022	Z 6AB4
V 702	Tube, Electron	11001	Z 0B2
V 703	Tube, Electron	11005	Z 12AX7
V 704	Tube, Electron	11007	Z 12AU7
V 705	Tube, Electron	11007	Z 12AU7
V 706	Tube, Electron	11005	Z 12AX7

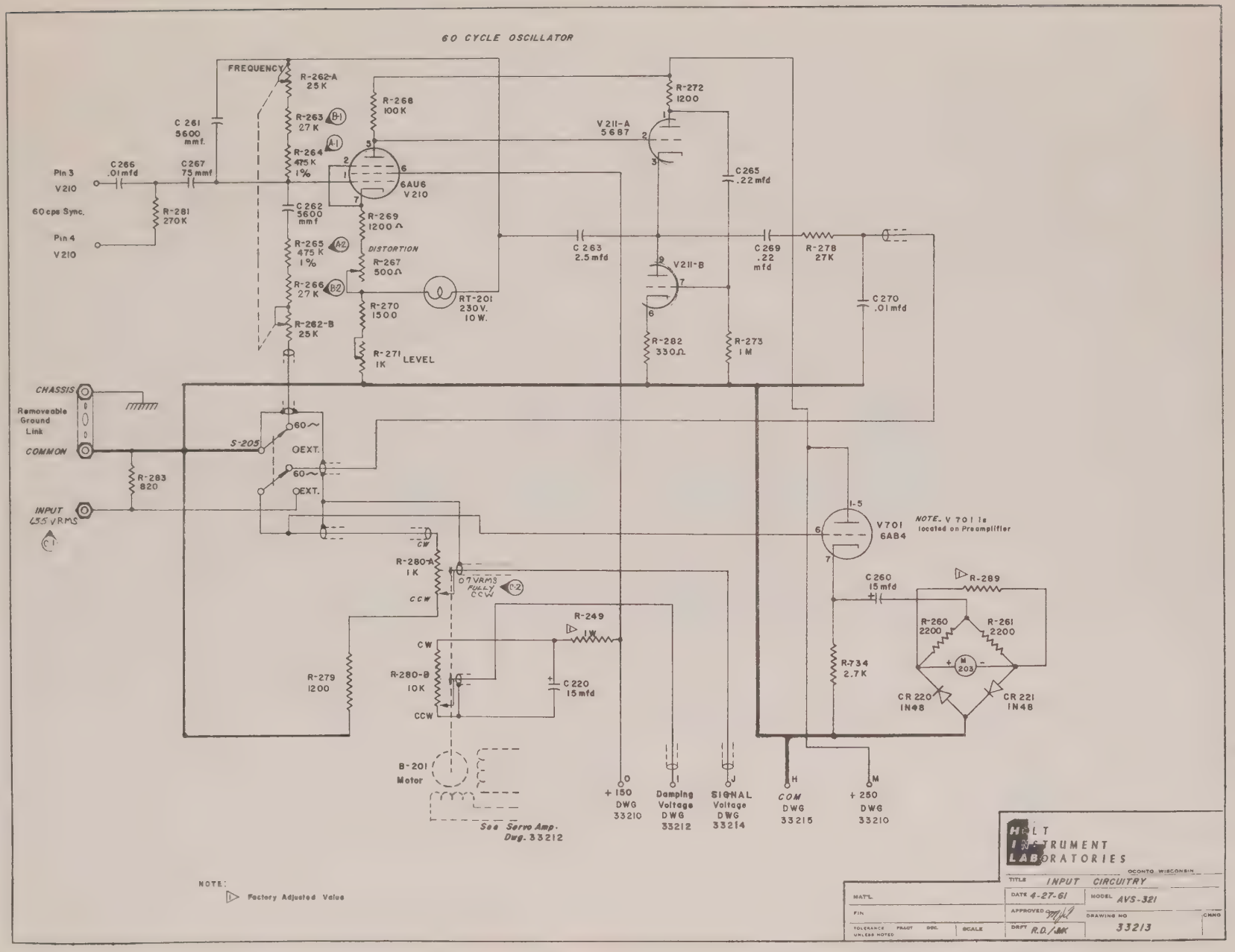
TABLE OF REPLACEABLE PARTS

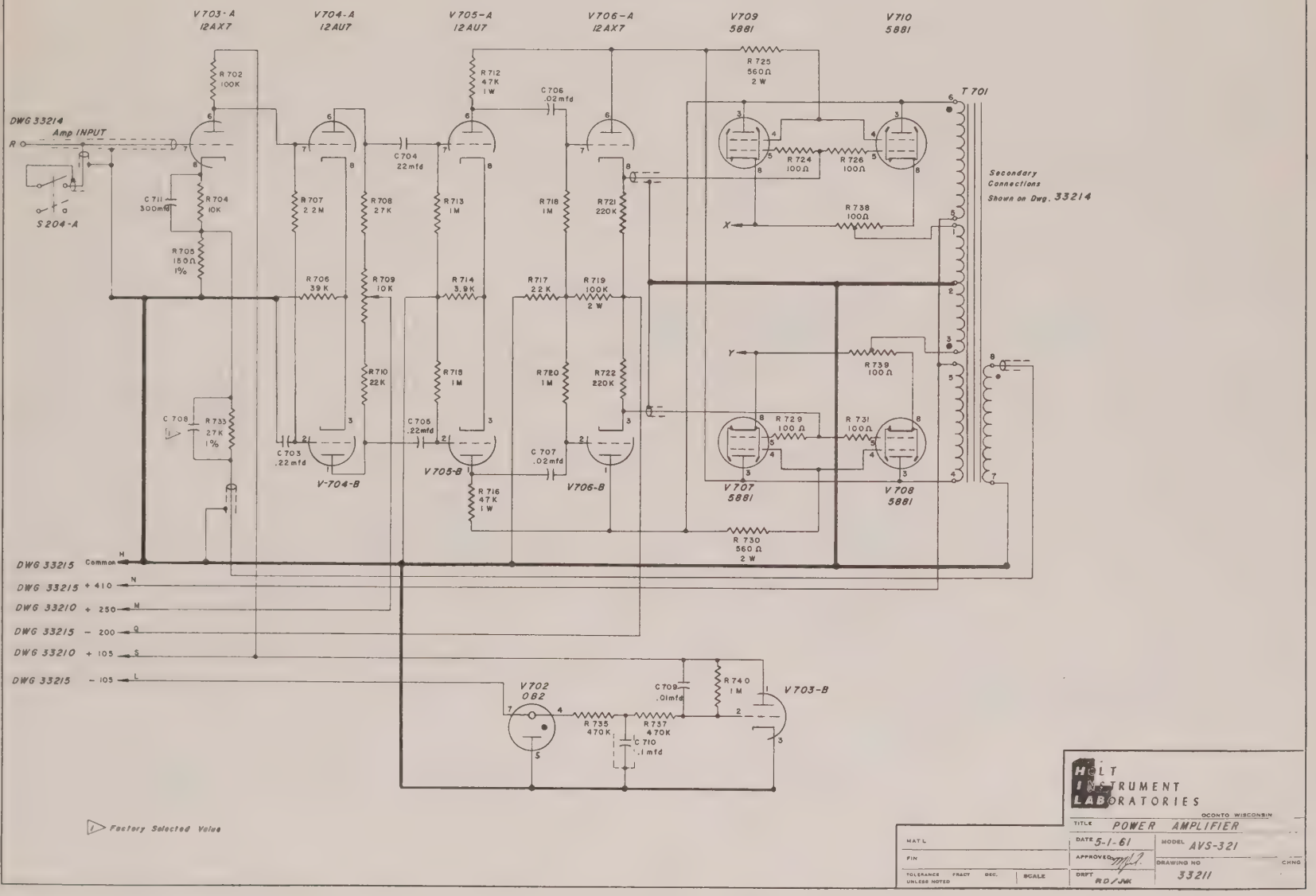
Circuit Ref.	Description	Holt Part No.	Mfr. & Mfr. Designation
V 707	Tube, Electron	11020	Z 5881
V 708	Tube, Electron	11020	Z 5881
V 709	Tube, Electron	11020	Z 5881
V 710	Tube, Electron	11020	Z 5881
Z 101	Chopper Input Network	51671	
Z 102	Referemce Voltage Oven Assembly Consisting of:	51670	
	Oven Temp. 55 C., 117 VAC	13105-055	DD NE62
	Zener Diode May be ordered separately	51674	
Z 103	60 Cycle Filter Network	51672	
Z 301	Parasitic Suppression Network Consists of 13 turns of #28 Wire Wound on 150 Ω, ½ Watt, ± 10% Composition Resistor (FF-RC-20)	51673	
Z 302	Parasitic Suppression Network Consists of 13 turns of #28 Wire Wound on 150 Ω, ½ Watt, ± 10% Composition Resistor (FF-RC-20)	51673	

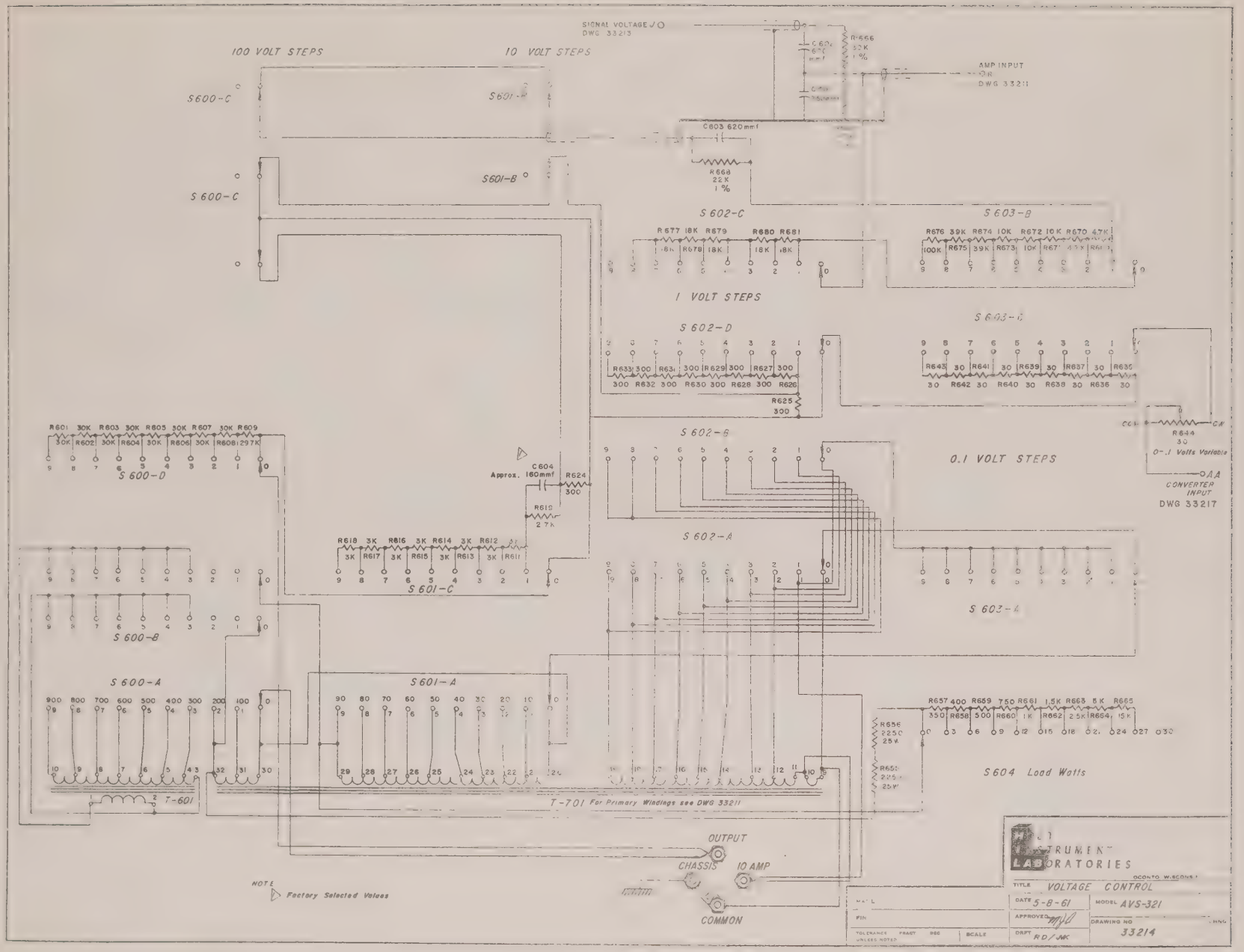


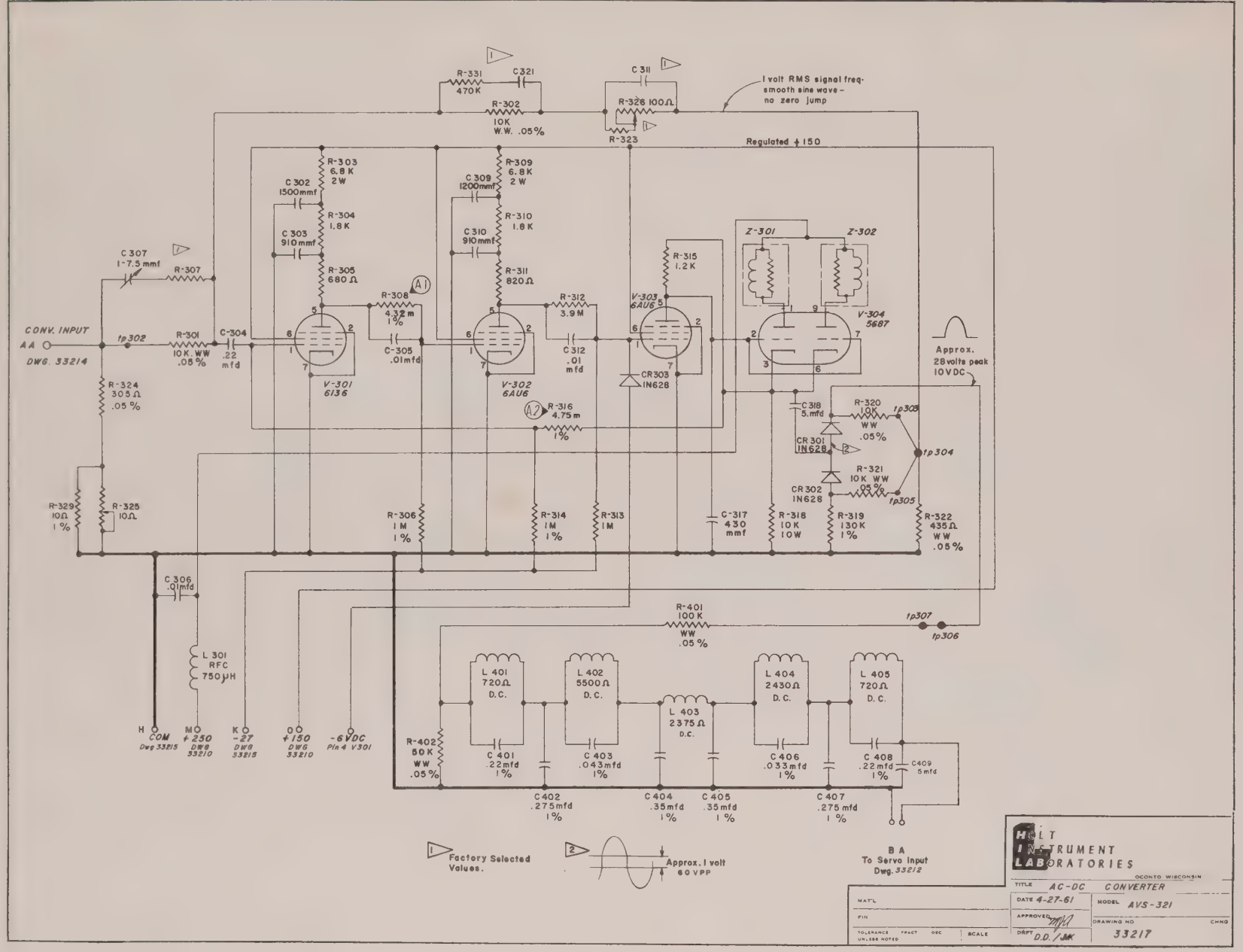
HILT INSTRUMENT LABORATORIES
OCONTO WISCONSIN

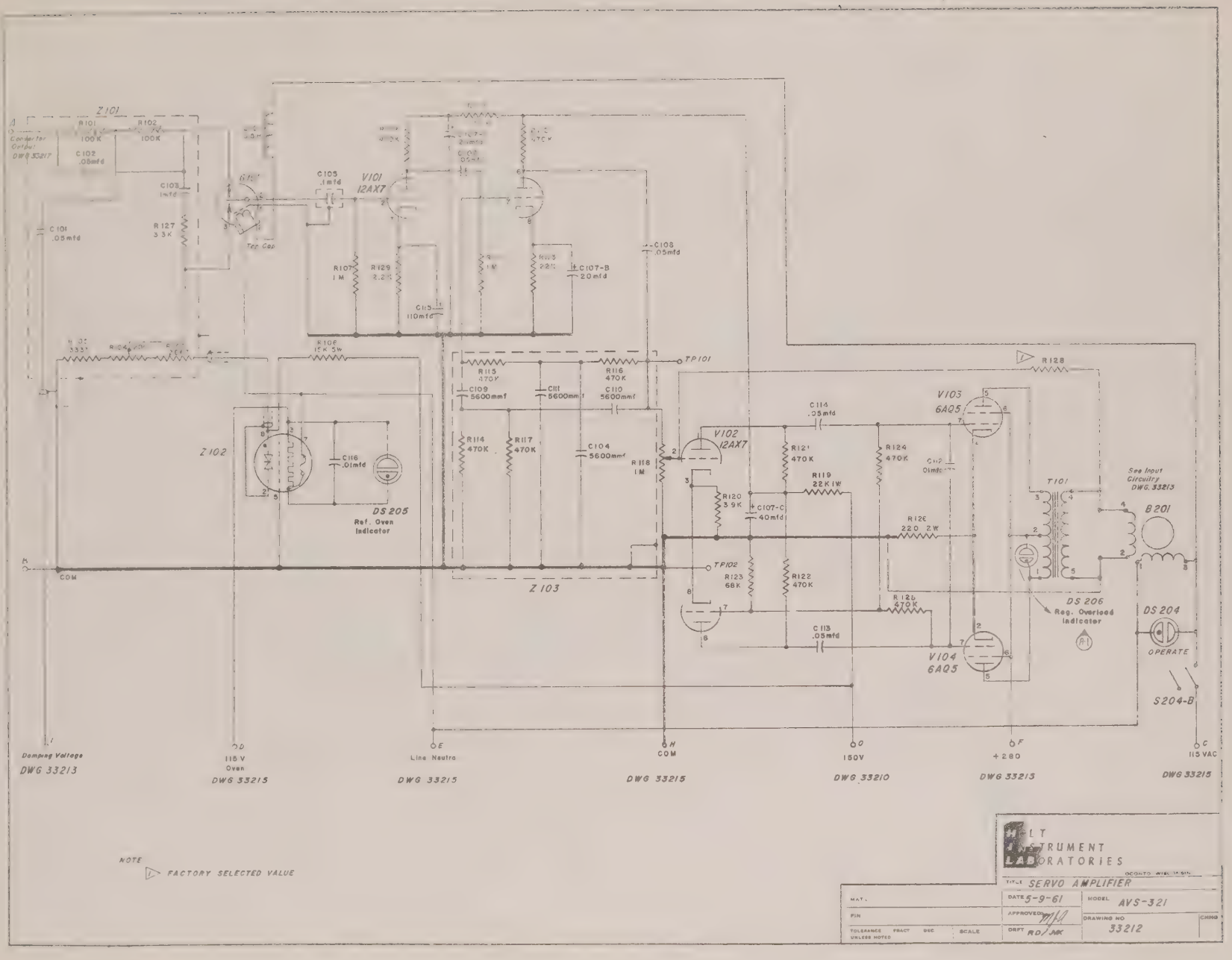
MAT'L		TITLE	BLOCK DIAGRAM
FIN		DATE	4-25-60
TOLERANCE UNLESS NOTED	FRACT DEC	SCALE	
		APPROVED	CPD
		DRFT	RLD
		MODEL	AVS-321
		DRAWING NO	1244
		CHNG	


60 CYCLE OSCILLATOR
FREQUENCY
R-262-A 25K
R-263 27 K
R-264 475 K 1%
R-268 100K
C 261 5600 mmf.
C 266 .01mfd
C 267 75 mmf
Pin 3 V210
60 cps Sync.
Pin 4 V210
R-281 270K
C 262 5600 mmf
R-265 475 K 1%
R-266 27K
R-262-B 25K
R-269 1200Ω
DISTORTION
R-267 500Ω
R-270 150Ω
R-271 1K LEVEL
RT-201 230V. 10W.
6AU6 V210
V211-A 5687
R-272 1200
C 265 .22 mfd
C 263 2.5 mfd
V211-B
C 269 .22 mfd
R-278 27K
C 270 .01 mfd
R-282 330Ω
R-273 1M
CHASSIS
Removeable Ground Link
COMMON
INPUT 4.35 VRMS
S-205
60~
EXT.
R-283 820
V701 6AB4
NOTE. V 701 is located on Preamplifier
R-280-A 1K
.07 VRMS FULLY CCW
CW
CCW
R-249 1W
R-279 1200
R-280-B 10K
C 220 15 mfd
C 260 15 mfd
R-289
R-260 2200
R-261 2200
M 203
R-734 2.7K
CR 220 IN48
CR 221 IN48
B-201 Motor
See Servo Amp. Dwg. 33212
O + 150 DWG 33210
I Damping Voltage DWG 33212
J SIGNAL Voltage DWG 33214
H COM DWG 33215
M + 250 DWG 33210
NOTE:
Factory Adjusted Value
HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN
TITLE INPUT CIRCUITRY
MATL
FIN
DATE 4-27-61
MODEL AVS-321
APPROVED
DRAWING NO 33213
TOLERANCE UNLESS NOTED
FRACT
DEC.
SCALE
DRFT R.D./MK
CHNG


V703-A 12AX7
V704-A 12AU7
V705-A 12AU7
V706-A 12AX7
V709 5881
V710 5881
R 702 100K
R 712 47K 1W
C 706 .02 mfd
R 725 560Ω 2W
T 701
DWG 33214
Amp INPUT
R
C 711 300mfd
R 704 10K
S 204-A
R 705 150Ω 1%
C 704 22 mfd
R 724 100Ω
R 726 100Ω
R 738 100Ω
X
Secondary Connections Shown on Dwg. 33214
R 707 2.2M
R 708 27K
R 713 1M
R 718 1M
R 721 220K
R 706 39K
R 709 10K
R 714 3.9K
R 717 2.2K
R 719 100K 2W
R 710 22K
R 715 1M
R 720 1M
R 722 220K
Y
R 739 100Ω
C 708
R 733 27K 1%
C 703 .22 mfd
C 705 .22 mfd
C 707 .02 mfd
R 729 100Ω
R 731 100Ω
V-704-B
V705-B
V706-B
V707 5881
V708 5881
R 716 47K 1W
R 730 560Ω 2W
DWG 33215 Common H
DWG 33215 + 410 N
DWG 33210 + 250 M
DWG 33215 − 200 Q
DWG 33210 + 105 S
DWG 33215 − 105 L
V702 082
C 709 .01mfd
R 740 1M
V703-B
R 735 470K
R 737 470K
C 710 .1 mfd
Factory Selected Value
HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN
TITLE POWER AMPLIFIER
MAT'L
FIN
TOLERANCE FRACT DEC. UNLESS NOTED
SCALE
DATE 5-1-61
APPROVED
DRFT RD/JWK
MODEL AVS-321
DRAWING NO 33211
CHNG


SIGNAL VOLTAGE I/O
DWG 33213
100 VOLT STEPS
10 VOLT STEPS
S600-C
S601-A
S601-B
S600-C
C603 620 mmf
R668 22K 1%
AMP INPUT
OR
DWG 33211
S602-C
S603-B
R677 18K R679 R680 R681
R676 39K R674 10K R672 10K R670 47K
1 VOLT STEPS
S602-D
S603-C
R633 300 R631 300 R629 300 R627 300
300 R632 300 R630 300 R628 300 R626
R625 300
R643 30 R641 30 R639 30 R637 30 R635
30 R642 30 R640 30 R638 30 R636 30
R644 30 0-.1 Volts Variable
CONVERTER INPUT
DWG 33217
R601 30K R603 30K R605 30K R607 30K R609
30K R602 30K R604 30K R606 30K R608 297K
S600-D
C604 Approx. 160mmf
R624 300
R610 2.7K
S602-B
0.1 VOLT STEPS
R618 3K R616 3K R614 3K R612
3K R617 3K R615 3K R613 3K R611
S601-C
S602-A
S603-A
S600-B
S600-A
S601-A
T-601
T-701 For Primary Windings see DWG 33211
R657 400 R659 750 R661 1.5K R663 5K R665
350 R658 500 R660 1K R662 2.5K R664 15K
R656 250 25W
R655 225 25W
S604 Load Watts
OUTPUT
CHASSIS
10 AMP
COMMON
NOTE
Factory Selected Values
LABORATORIES
OCONTO WISCONSIN
TITLE VOLTAGE CONTROL
DATE 5-8-61
MODEL AVS-321
APPROVED
DRAWING NO 33214
DRAFT RD/MK
SCALE
TOLERANCE UNLESS NOTED

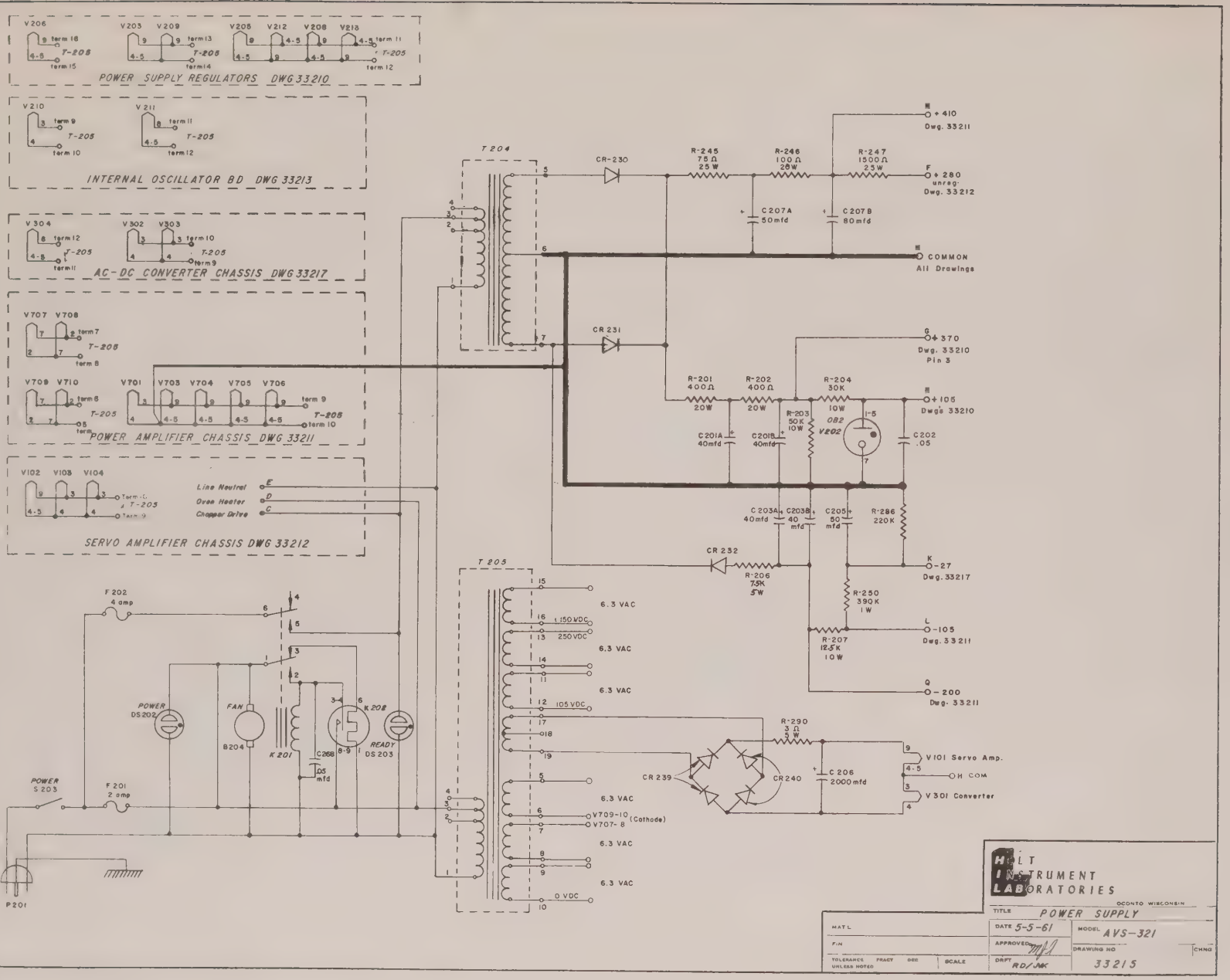

R-331 470K
C321
C311
R-302 10K W.W. .05%
R-326 100Ω
R-323
1 volt RMS signal freq-smooth sine wave-no zero jump
Regulated +150
R-303 6.8K 2W
C302 1500mmf
R-304 1.8K
C303 910mmf
R-305 680Ω
R-309 6.8K 2W
C309 1200mmf
R-310 1.8K
C310 910mmf
R-311 820Ω
C307 1-7.5mmf
R-307
R-308 4.32m 1%
C-305 .01mfd
R-312 3.9M
C312 .01 mfd
V-303 6AU6
R-315 1.2K
Z-301
Z-302
V-304 5687
CONV. INPUT AA DWG. 33214
tp302
R-301 10K. WW .05%
C-304 .22 mfd
V-301 6136
V-302 6AU6
CR303 IN628
Approx. 28 volts peak 10VDC
R-316 4.75m 1%
C318 5.mfd
R-320 10K WW .05%
tp303
CR301 IN628
tp304
R-321 10K WW .05%
CR302 IN628
tp305
R-324 305Ω .05%
R-329 10Ω 1%
R-325 10Ω
R-306 1M 1%
R-314 1M 1%
R-313 1M
C-317 430 mmf
R-318 10K 10W
R-319 130K 1%
R-322 435Ω WW .05%
C306 .01mfd
R-401 100K WW .05%
tp307
tp306
L 301 RFC 750μH
L 401 720Ω D.C.
L 402 5500Ω D.C.
L 403 2375Ω D.C.
L 404 2430Ω D.C.
L 405 720Ω D.C.
H COM Dwg 33215
M +230 DWG 33210
K -27 DWG 33215
O +150 DWG 33210
-6VDC Pin 4 V301
R-402 50K WW .05%
C 401 .22mfd 1%
C 403 .043mfd 1%
C 406 .033mfd 1%
C 408 .22mfd 1%
C409 5mfd
C 402 .275mfd 1%
C 404 .35mfd 1%
C 405 .35mfd 1%
C 407 .275mfd 1%
1 Factory Selected Values.
2 Approx. 1 volt 60 VPP
B A To Servo Input Dwg. 33212
HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN
TITLE AC-DC CONVERTER
MAT'L
FIN
DATE 4-27-61
MODEL AVS-321
APPROVED
DRAWING NO 33217
DRFT D.D.
TOLERANCE UNLESS NOTED FRACT DEC SCALE

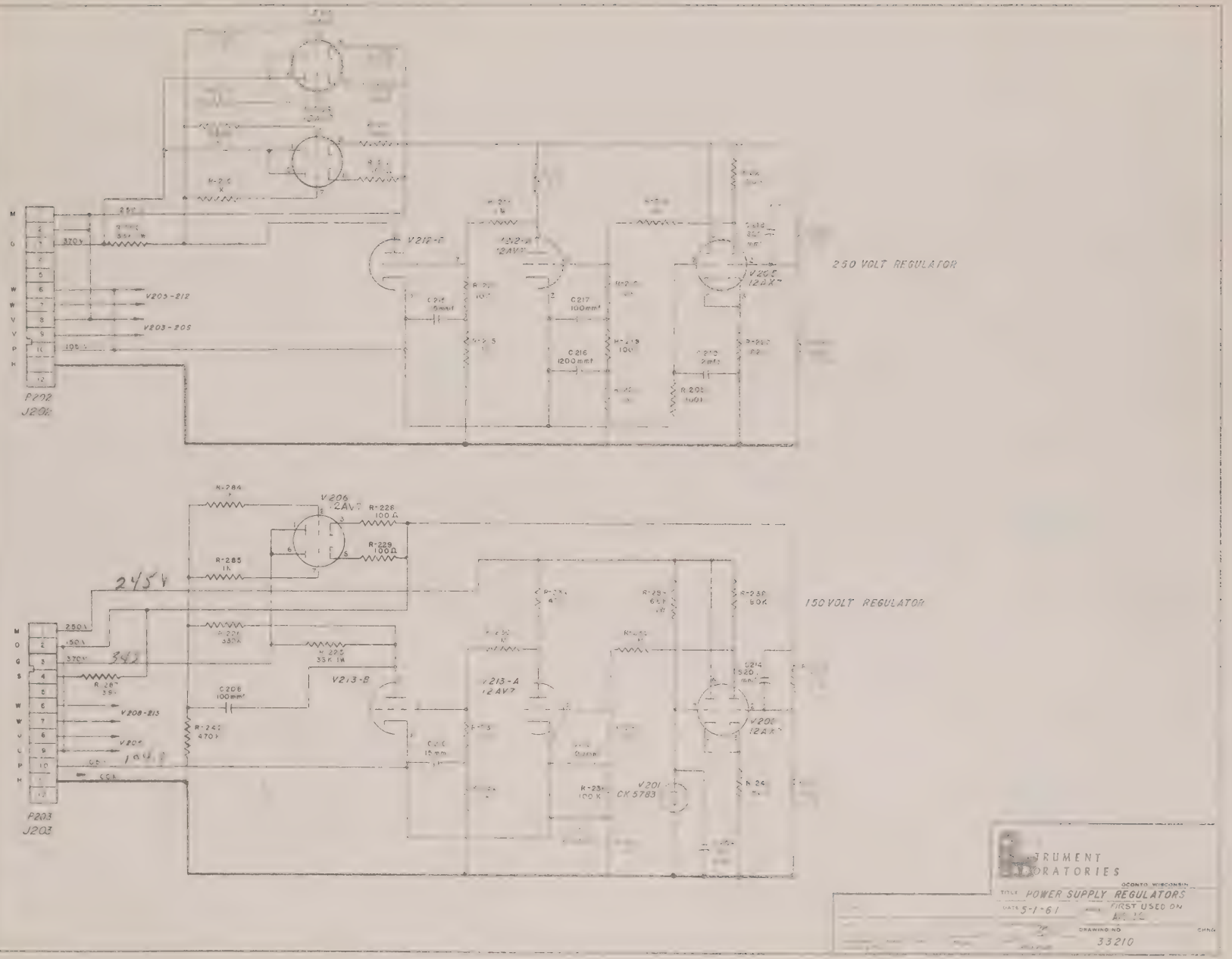


NOTE

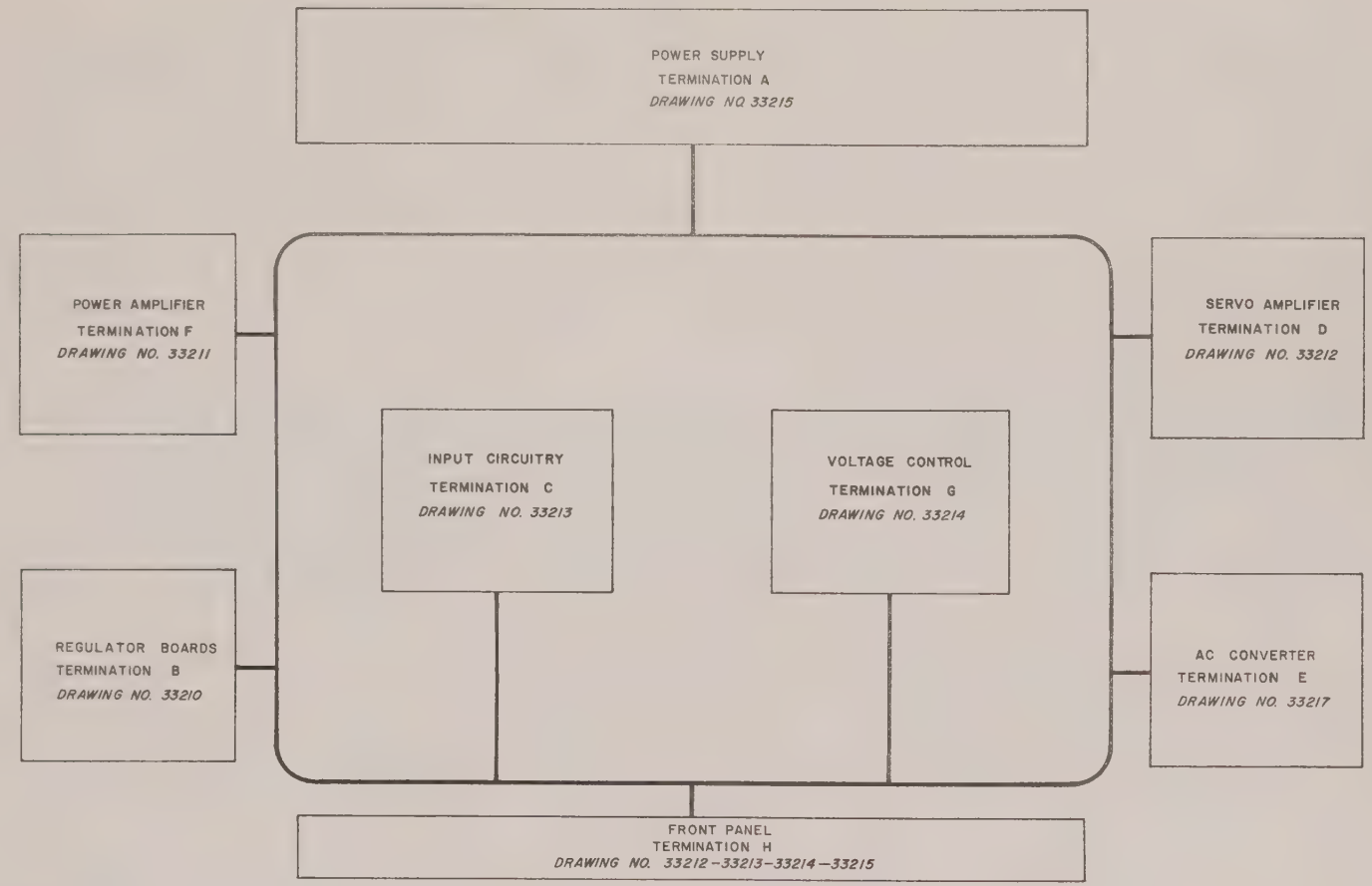
▷ FACTORY SELECTED VALUE

		TITLE SERVO AMPLIFIER	
MAT.	DATE 5-9-61	MODEL AVS-321	
FIN	APPROVED	DRAWING NO 33212	CHNG
TOLERANCE FRACT DEC ANG UNLESS NOTED	SCALE	DRFT RD/JAK	


POWER SUPPLY REGULATORS DWG 33210
INTERNAL OSCILLATOR BD DWG 33213
AC-DC CONVERTER CHASSIS DWG 33217
POWER AMPLIFIER CHASSIS DWG 33211
SERVO AMPLIFIER CHASSIS DWG 33212
T-205
T-208
T-203
T 204
T 205
CR-230
CR 231
CR 232
CR 239
CR 240
R-245 75Ω 25 W
R-246 100Ω 20W
R-247 1500Ω 25W
C 207A 50mfd
C 207B 80mfd
R-201 400Ω 20W
R-202 400Ω 20W
R-204 30K 10W
R-203 50K 10W
C 201A 40mfd
C 201B 40mfd
C 202 .05
C 203A 40mfd
C 203B 40 mfd
C 205 50 mfd
R-286 220K
R-206 7.5K 5W
R-250 390K 1W
R-207 12.5K 10W
R-290 3Ω 3W
C 206 2000mfd
C 268 .05 mfd
F 202 4 amp
F 201 2 amp
POWER S 203
POWER DS 202
FAN B 204
K 201
K 208
READY DS 203
P 201
+ 410 Dwg. 33211
+ 280 unreg. Dwg. 33212
COMMON All Drawings
+ 370 Dwg. 33210 Pin 3
+ 105 Dwg. 33210
- 27 Dwg. 33217
- 105 Dwg. 33211
- 200 Dwg. 33211
6.3 VAC
150 VDC
250 VDC
105 VDC
0 VDC
V709-10 (Cathode)
V707- 8 (Cathode)
V101 Servo Amp.
H COM
V301 Converter
Line Neutral
Oven Heater
Chopper Drive
HALT INSTRUMENT LABORATORIES
OCONTO WISCONSIN
TITLE POWER SUPPLY
MODEL AVS-321
DRAWING NO 33215
DATE 5-5-61
APPROVED
DRFT RD/JNK



INSTRUMENT LABORATORIES
OCONTO, WISCONSIN
TITLE POWER SUPPLY REGULATORS
DATE 5-1-61 FIRST USED ON
DRAWING NO 33210



NOTE: THE CONDUCTOR NUMBER IS THE SAME AT BOTH ENDS OF THE CONDUCTOR;
THE TERMINATION LETTER INDICATES THE SUBASSEMBLY ON WHICH THE CONDUCTOR TERMINATES.

HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN

MAT'L		TITLE BLOCK DIAGRAM Wiring Harness	
FIN		DATE 5-11-61	MODEL AVS-321
TOLERANCE UNLESS NOTED FRACT DEC	SCALE	APPROVED MJA	DRAWING NO 33216 CHNG
		DRFT RLD	

TERMINATION "A" - POWER SUPPLY

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
1	D	+280 R-247	F	Purp/Blk
2	A	R201		Buss
2	A	CR231 (Red Dot)		Buss
5	D	C-206		Tan
7	D	Com.	H	Blk
8	D	Line Neut.	E	Wht
9	D	T-205 Pin 9	Z	Brn/W
10	D	T-205 Pin 10	Z	Yel
17	A	-27 R-250	K	Brn
17	A	C-205		Brn
18	E	Com.	H	Blk
21	E	T-205 Pin 9	Z	Brn/Wht
22	E	T-205 Pin 10	Z	Yel
23	E	C-206		Brn/Wht
27	C	T-205 Pin 10	Z	Yel
28	C	T-205 Pin 9	Z	Brn/Wht
31	C	Com.	H	Blk
34	F	-105 R-207	L	Gry/Wht
35	F	T-205 Pin 10	Z	Yel
36	F	T-205 Pin 9	Z	Brn/Wht
37	F	-200 R-206	Q	Blu/Wht
38	F	Com.	H	Blk
40	F	T-205 Pin 5	X	Brn/Wht
41	F	T-205 Pin 6	X	Pink
42	F	T-205 Pin 7	Y	Brn/Wht
43	F	T-205 Pin 8	Y	Blu
46	F	+410 R-246	N	Dk.Blu
57	B	+105 R-204	P	Pnk
59	B	Com.	H	Blk
61	B	+370 R-202	G	Purp/Wht
62	B	T-205 Pin 12	W	Brn
63	B	T-205 Pin 11	W	Brn/Wht
65	B	T-205 Pin 13	V	Brn/Wht
66	B	T-205 Pin 14	V	Red
67	B	T-205 Pin 15	U	Brn/Wht
68	B	T-205 Pin 16	U	Grn
69	E	T-205 Pin 11	W	Brn/Wht
70	E	T-205 Pin 12	W	Brn
71	C	T-205 Pin 11	W	Brn/Wht
72	C	T-205 Pin 12	W	Brn
79	A	Earth Grd.	(115 VAC)	Grn
80	H	115 VAC	(Power)	Blk
81	A	Line Neut.	(Cord)	Wht

TERMINATION "A" - POWER SUPPLY

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
79	A	Chassis Gnd		Grn
81	A	Line Neut.	E	Wht
83	H	K-201 Pin 1		Orn
88	H	B-204		Purp/Blk
91	H	Line Neut.	E	Wht
92	D	B-204		Wht
94	H	K-201 Pin 5		Brn/Blk
96	D	Line Neut.	E	Wht
100	H	K-201 Pin 6		Red
101	A	K-201 Pin 1		Orn
101	A	K-202 Pin 8		Orn
102	A	K-201 Pin 3		Dk.Blu
102	A	K-202 Pin 6		Dk.Blu
103	A	K-201 Pin 2		Tan
103	A	K-202 Pin 4		Tan
104	A	K-201 Pin 4		Blu
104	A	T-204 Pin 3		Blu
107	A	K-201 Coil		Wht
107	A	Line Neut.	E	Wht
109	A	T-204 Pin 1		Wht
109	A	Line Neut.	E	Wht
110	A	T-204 Pin 5		Red
111	A	CR230		Red
110	A	CR-230		Red
111	A	CR232+		Red
112	A	T-204 Pin 6		Blk
113	A	T-204 Pin 6		Blk
114	A	T-204 Pin 6		Blk
112	A	C-207		Blk
113	A	C-201		Blk
114	A	Com.	H	Blk
115	A	C-207		Blk
115	A	Com.	H	Blk
116	A	CR230 (Red Dot)		Buss
117	A	T-204 Pin 7		Red/Wht
116	A	R201		Buss
117	A	CR-231		Red/Wht
118	A	R-201		Orn
118	A	C-201A		Orn
119	A	C-201A		Orn
119	A	R-202		Orn

TERMINATION "A" - POWER SUPPLY

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
120	A	C-201 B		Yel
120	A	+370 R-202	G	Yel
121	A	R-203		Blk
121	A	Com.	H	Blk
122	A	R-204		Yel/Blk
122	A	V-202 Pin 1		Yel/Blk
123	A	R-206		Grn
123	A	C-203		Grn
124	A	C-203		Grn
124	A	R-207		Grn
125	E	-27 C-205	K	Brn
126	A	C-205		Blk
126	A	Com.	H	Blk
127	A	C-203		Blk
127	A	Com.	H	Blk
128	A	V-202 Pin 7		Blk
128	A	Com.	H	Blk
129	A	CR-231		Blu/Blk
129	A	R-245		Blu/Blk
130	A	R-245		Red/Blk
130	A	C-207A		Red/Blk
131	A	R-246		Purp
131	A	C-207B		Purp
132	A	K-202 Pin 9		Red
132	A	T-205 Pin 3		Red
133	A	T-205 Pin 1		Wht
133	A	Line Neut.		Wht
134	A	T-205 Pin 17		Orn/Blk
134	A	CR-240		Orn/Blk
135	A	T-205 Pin 19		Orn/Blk
135	A	CR-239		Orn/Blk
136	A	CR-239 & 240		Brn/Wht
136	A	C-206		Brn/Wht
137	A	R-290		Tan
137	A	CR-239 & 240		Tan
138	A	R-290		Tan
138	A	C-206		Tan
193	F	Com.	H	Blk

TERMINATION "B" - VOLTAGE REGULATORS

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
4	D	J-203 Pin 2 +150	O	Yel/Wht
19	E	J-203 Pin 1 +250	M	Orn/Wht
20	E	J-203 Pin 2 +150	O	Yel/Wht
29	C	J-202 Pin 1 +250	M	Red/Wht
30	C	J-203 Pin 2 +150	O	Yel
32	C	J-203 Pin 2 +150	O	Gry/Blk
33	F	J-203 Pin 4 +105	S	Orn/Blk
39	F	J-202 Pin 1 +250	M	Orn/Wht
53	B	J-202 Pin 1 +250	M	Orn/Wht
53	B	J-203 Pin 1 +250	M	Orn/Wht
54	B	J-202 Pin 3 +370	G	Purp/Wht
54	B	J-203 Pin 3 +370	G	Purp/Wht
55	B	J-202 Pin 6 Fil	W	Brn
56	B	J-202 Pin 7 Fil	W	Brn/Wht
55	B	J-203 Pin 6 Fil	W	Brn
56	B	J-203 Pin 7 Fil	W	Brn/Wht
57	A	J-202 Pin 10 +105	P	Pnk
58	B	J-202 Pin 10 +105	P	Pnk
58	B	J-203 Pin 10 +105	P	Pnk
59	A	J-202 Pin 11 Com	H	Blk
60	B	J-202 Pin 11 Com	H	Blk
60	B	J-203 Pin 11 Com	H	Blk
61	A	J-203 Pin 3 +370	G	Purp/Wht
62	A	J-203 Pin 6 Fil	W	Brn
63	A	J-203 Pin 7 Fil	W	Brn/Wht
65	A	J-202 Pin 8 Fil	V	Brn/Wht
66	A	J-202 Pin 9 Fil	V	Red
67	A	J-203 Pin 8 Fil	U	Brn/Wht
68	A	J-203 Pin 9 Fil	U	Grn

TERMINATION "C" - INPUT CIRCUIT

16	D	Servo Pot Arm 10K	I	Shld
25	G	Servo Pot Arm 1K	J	Shld
27	A	V-210 Pin 4	Z	Yel
28	A	V-210 Pin 3	Z	Brn/Wht
29	B	Oscillator Board R-268	M	Red/Wht
30	B	V-210 Pin 6 +150	O	Yel
31	A	Oscillator Board Com.	H	Blk
32	B	R-249 +150	O	Gry/Blk
50	H	V-701 Pin 7		Grn/Blk
71	A	V-211 Pin 8	W	Brn/Wht
72	A	V-211 Pin 4	W	Brn
74	H	Servo Pot 1K CW		Shld
75	H	R-279		Purp
78	H	V-701 Pin 6		Red/Wht
108	C	Servo Pot		Red/Wht
108	C	R-249		Red/Wht
187	C	Servo Pot 1K CCW		Blu
187	C	R-279		Blu

TERMINATION "D" - SERVO AMPLIFIER

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
1	A	T-101 Pin 2	F	Purp/Blk
4	B	+150 VDC	O	Yel/Wht
5	A	+6 V-101 Pin 9		Tan
6	E	V-101 Pin 4		Dk.Blu
7	A	Com.	H	Blk
8	A	Z-102 Pin 7		Wht
9	A	V-104 Pin 4	Z	Brn/Wht
10	A	V-104 Pin 3	Z	Yel
11	E	Z-101		Grn/Wht
12	E	Z-101		Blk
13	D	T-101 Pin 5		Orn
13	D	B-201 Pin 2		Orn
14	D	T-101 Pin 4		Grn
14	D	B-201 Pin 4		Grn
15	H	Z-102 Pin 1		Blu/Blk
16	C	Z-101		Shld
84	H	Z-102 Pin 3	D	Blk/Wht
92	A	B-201 Pin 1		Wht
95	H	B-201 Pin 3		Red/Blk
96	A	B-201 Pin 1	E	Wht
97	H	L-101	C	Blu/Wht
98	H	T101 Pin 1		Purp/Wht
99	H	T101 Pin 2		Gry
105	D	L-101		Purp
105	D	Chopper Cap Pin 2		Purp
106	D	Chopper Cap Pin 1		Wht
106	D	Z-102 Pin 7		Wht
189	D	T-101 Pin 2	F	Purp/Blk
189	D	V-103 Pin 6		Purp/Blk
190	D	T-101 Pin 1		Blu
190	D	V-104 Pin 5		Blu
191	D	T-101 Pin 3		Grn/Wht
191	D	V-103 Pin 5		Grn/Wht

TERMINATION "E" - AC-DC CONVERTER

6	D	V-301 Pin 3		Dk.Blu
11	D	Conv. Output	A	Grn/Wht
12	D	Conv. Output	B	Blk
18	A	Com.	H	Blk
19	B	+250 VDC	M	Orn/Wht
20	B	+150 VDC	O	Yel/Wht
21	A	V-303 Pin 4	Z	Brn/Wht
22	A	V-303 Pin 3	Z	Yel
23	A	-6 VDC V-301 Pin 4		Brn/Wht
24	G	Conv. Input	AA	Grn
69	A	V-304 Pin 4	W	Brn/Wht
70	A	V-304 Pin 8		Brn
125	A	-27 VDC	K	Brn

TERMINATION "E" - AC-DC CONVERTER

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
6	D	V-301 Pin 3		Dk.Blu
11	D	Conv. Output	A	Grn/Wht
12	D	Conv. Output	B	Blk
18	A	Com.	H	Blk
19	B	+250 VDC	M	Orn/Wht
20	B	+150 VDC	O	Yel/Wht
21	A	V-303 Pin 4	Z	Brn/Wht
22	A	V-303 Pin 3	Z	Yel
23	A	-6 VDC V-301 Pin 4		Brn/Wht
24	G	Conv. Output	AA	Grn
69	A	V-304 Pin 4	W	Brn/Wht
70	A	V-304 Pin 8		Brn
125	A	-27 VDC	K	Brn

TERMINATION "F" - POWER AMPLIFIER

26	G	Amp. Input	R	Shld
33	B	+105 V-703 Pin 1	S	Orn/Blk
34	A	-105 V-702	L	Gry/Wht
35	A	V-706 Pin 4	Z	Yel
36	A	V-706 Pin 9	Z	Brn/Wht
37	A	-200 R-719	Q	Blu/Wht
38	A	Com.	H	Blk
39	B	+250 V-701 Pin 1	M	Orn/Wht
40	A	V-709 Pin 2	X	Brn/Wht
41	A	V-709 Pin 7	X	Pink
42	A	V-708 Pin 2	Y	Brn/Wht
43	A	V-708 Pin 7	Y	Blu
44	F	Feedback R-733		Shld
44	F	T-701 Pin 8		Shld
45	H	Amp. Input	R	Shld
46	A	+410 T-701 Pin 5	N	Dk.Blu
47	F	V-706 Pin 1		Brn
47	F	T-701 Pin 6		Brn
48	F	V-706 Pin 6		Red/Blk
48	F	T-701 Pin 4		Red/Blk
49	F	V-701 Pin 5		Orn/Wht
49	F	R-709 Arm		Orn/Wht
51	F	R-738		Blk/Wht
51	F	T-701 Pin 3		Blk/Wht
52	F	R-739		Pink
52	F	T-701 Pin 1		Pink
142	F	T-701 Pin 2		Blk
142	F	T-701 Pin 7		Blk
193	A	T-701 Pin 2		Blk

TERMINATION "G" - VOLTAGE CONTROL

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
24	E	Converter Input	AA	Grn
25	C	R-666 & C-602	J	Shld
26	F	R-666 & R-667	R	Shld
139	H	T-701 Pin 9		Wht
140	H	T-701 Pin 9		Wht
141	H	T-701 Pin 10		Red
142	H	T-701 Pin 12		Brn
143	H	T-701 Pin 13		Red
144	H	T-701 Pin 14		Orn
145	H	T-701 Pin 15		Yel
146	H	T-701 Pin 16		Grn
147	H	T-701 Pin 17		Blu
148	H	T-701 Pin 18		Purp
149	H	T-701 Pin 19		Gry
150	H	T-701 Pin 21		Red/Wht
151	H	T-701 Pin 22		Orn/Wht
152	H	T-701 Pin 23		Yel/Wht
153	H	T-701 Pin 24		Grn/Wht
154	H	T-701 Pin 25		Blu/Wht
155	H	T-701 Pin 26		Purp/Wht
156	H	T-701 Pin 27		Pink
157	H	T-701 Pin 28		Dk.Blu
158	H	T-701 Pin 29		Tan
159	H	T-701 Pin 29		Red/Wht
160	H	T-701 Pin 30		Brn
161	H	T-701 Pin 31		Wht
162	H	T-701 Pin 32		Gry/Wht
163	H	T-701 Pin 32		Grn/Wht
165	H	T-601 Pin 1		Tan
166	H	T-601 Pin 2		Brn/Wht
167	H	T-601 Pin 4		Orn
168	H	T-601 Pin 5		Yel
169	H	T-601 Pin 6		Grn
170	H	T-601 Pin 7		Blu
171	H	T-601 Pin 8		Purp
172	H	T-601 Pin 9		Gry
173	H	T-601 Pin 10		Red
176	H	S-600-A Arm		Purp/Wht
177	H	R-657		Brn
178	H	R-658		Red
179	H	R-659		Orn
180	H	R-660		Yel
181	H	R-661		Grn
182	H	R-662		Blu
183	H	R-663		Purp
184	H	R-664		Gry
185	H	R-665		Pink
186	H	R-665		Dk.Blu

TERMINATION "H" - FRONT PANEL

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
15	D	DS-205		Blu/Blk
45	F	S-204 A		Shld
50	C	C260		Grn/Blk
64	H	DS-203		Blu
64	H	S-204 B		Blu
73	H	Sig. Input Term.		Red
73	H	S-205		Red
74	C	S-205		Shld
75	C	Input Com.		Purp
76	H	Input Com.		Blk
77	H	Input Com.		Blu/Wht
76	H	S-205		Blk
77	H	CR220 & CR221		Blu/Wht
78	C	S-205		Red/Wht
80	A	S-203		Blk
82	H	F-201		Pnk
82	H	DS-205		Pnk
83	A	F-201		Orn
84	D	F-201		Blk/Wht
85	H	S-203		Blu
85	H	F-201		Blu
86	H	S-203		Grn/Wht
86	H	F-202		Grn/Wht
87	H	F-201		Grn
87	H	DS-202		Grn
88	A	F-201		Purp/Blk
89	H	DS-202		Wht
89	H	DS-203		Wht
90	H	DS-203		Wht
90	H	DS-204		Wht
91	A	DS-204		Wht
93	H	DS-204		Grn/Blk
93	H	S-204 B		Grn/Blk
94	A	S-204 B		Brn/Blk
95	D	S-204 B		Red/Blk
97	D	S-204 B		Blu/Wht
98	D	DS-206		Purp/Wht
99	D	DS-206		Gry
100	A	F-202		Red
139	G	Output Com. Term.		Wht
140	G	0 Pos. S-602 A		Wht
141	G	10 Amp. Output		Red

TERMINATION "H" - FRONT PANEL

Cond.	Term. Letter	Termination Point	Schematic Ref. Des.	Color
142	G	2 Pos. S-602 A		Brn
143	G	3 Pos. S-602 A		Red
144	G	4 Pos. S-602 A		Orn
145	G	5 Pos. S-602 A		Yel
146	G	6 Pos. S-602 A		Grn
147	G	7 Pos. S-602 A		Blu
148	G	8 Pos. S-602 A		Purp
149	G	9 Pos. S-602 A		Gry
150	G	1 Pos. S-601 A		Red/Wht
151	G	2 Pos. S-601 A		Orn/Wht
152	G	3 Pos. S-601 A		Yel/Wht
153	G	4 Pos. S-601 A		Grn/Wht
154	G	5 Pos. S-601 A		Blu/Wht
155	G	6 Pos. S-601 A		Purp/Wht
156	G	7 Pos. S-601 A		Pnk
157	G	8 Pos. S-601 A		Dk.Blu
158	G	9 Pos. S-601 A		Tan
159	G	Arm S-604		Red/Wht
160	G	0 Pos. S-601 A		Brn
161	G	1 Pos. S-600 A		Wht
162	G	2 Pos. S-600 A		Gry/Wht
163	G	S-604		Grn/Wht
164	H	S-604		Grn/Wht
164	H	R-655		Grn/Wht
165	G	Arm S-600 B		Tan
166	G	Pos. 3 S-600 B		Brn/Wht
167	G	Pos. 3 S-600 A		Orn
168	G	Pos. 4 S-600 A		Yel
169	G	Pos. 5 S-600 A		Grn
170	G	Pos. 6 S-600 A		Blu
171	G	Pos. 7 S-600 A		Purp
172	G	Pos. 8 S-600 A		Gry
173	G	Pos. 9 S-600 A		Red
174	H	Arm S-600 A		Wht
174	H	Output Term.		Wht
175	H	Pos. 1 S-602 A		Blk
175	H	10 Amp. Output		Blk
176	G	Output Term.		Purp/Wht
177	G	0 Pos. S-604		Brn
178	G	3 Pos. S-604		Red
179	G	6 Pos. S-604		Orn
180	G	9 Pos. S-604		Yel
181	G	12 Pos. S-604		Grn
182	G	15 Pos. S-604		Blu
183	G	18 Pos. S-604		Purp
184	G	21 Pos. S-604		Gry
185	G	24 Pos. S-604		Pnk
186	G	27 Pos. S-604		Dk.Blu
188	H	Output Gnd. Term.		Grn
188	H	Chassis Gnd.		Grn
192	H	Input Gnd. Term.		Grn
192	H	Chassis Gnd.		Grn

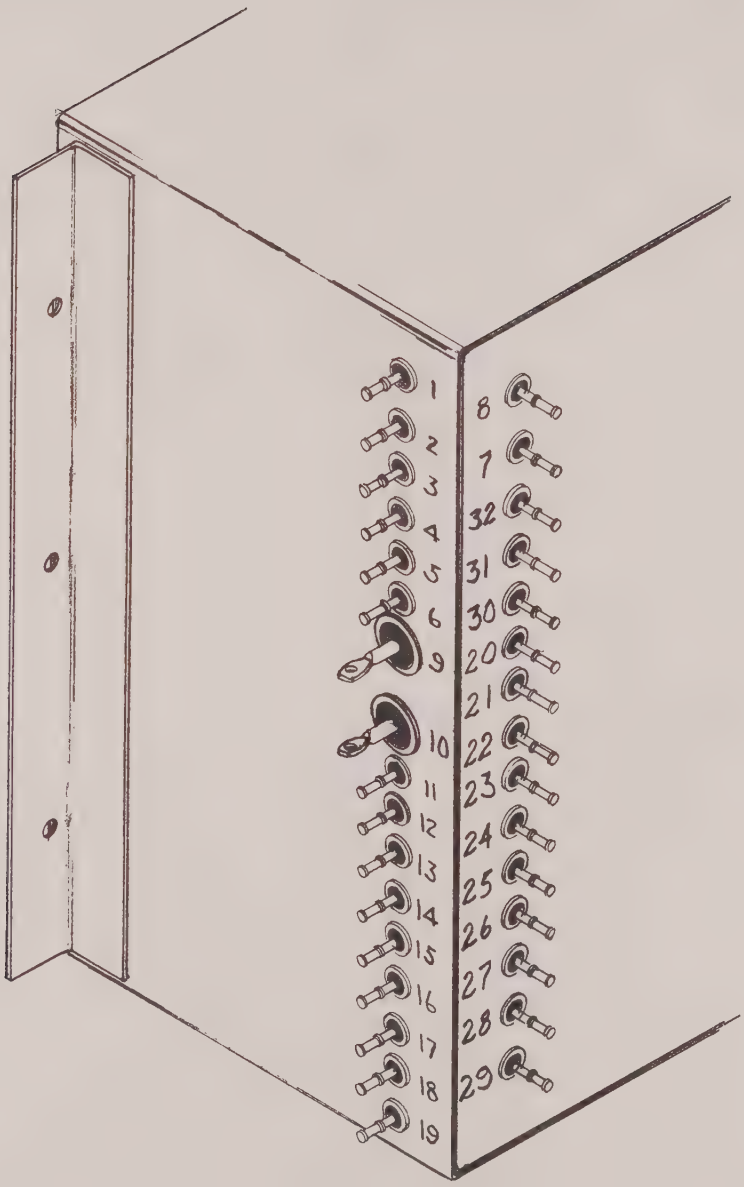

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Fig. 8-1

SPECIAL APPLICATIONS:

In addition to using the AVS-321 for the calibration of single voltmeters in its normal operating range a number of additional uses deserve comment.

VOLTAGE CALIBRATION:

Group Accuracy Checks: Many companies have large quantities of lower accuracy voltmeters which are checked for accuracy of calibration at 30 to 60 day intervals. Since the AVS-321 is not affected by loading, a group of these instruments may be connected to the AVS-321 simultaneously thereby saving a considerable amount of calibration time. The best procedure is to set the AVS-321 to a voltage equal to a cardinal point voltage plus the tolerance and check all the meters under test to see that they read above the cardinal point. Then set the AVS-321 to the cardinal voltage minus the tolerance and check all meters for a reading below the cardinal point. The operator knows that meters reading below the cardinal point in the first test and above in the second test need repair or adjustment. He does not have to make any quantative readings of the meters.

Extended Frequency Operation: The frequency range of the AVS-321 is limited by two factors. The range over which accurate calibration may be obtained is limited by the response of the attenuator and AC-DC converter. However, the unit may be operated as a stable, low distortion source at somewhat higher frequencies up to the limits of the power amplifier output transformers if the absolute voltage is calibrated by external measurement.

The low voltage output transformer will provide voltages up to 299 volts at frequencies up to 15 KC. Depending on the individual transformer characteristics, some units may operate as high as 20 KC with good waveform.

At outputs of 300 volts and above, a high voltage step-up transformer is internally connected to the amplifier output. This transformer becomes resonant at frequencies above 5 KC forming the high voltage upper limit. It can usually be used to 4 KC with good waveform depending on loading.

When using the AVS-321 at frequencies above its specified operating range it is best to monitor the output waveform with a scope and distortion analyzer to assure operation within these transformer limitations.

USE AS A CURRENT SOURCE:

The AVS-321 may also be used as a stable source of alternating current for the calibration of AC ammeters.

At current levels up to 3 amps the ammeter under test and the standard ammeter should be connected in series with a suitable current limiting resistor and the output terminals of the AVS-321. If the limiting resistor R_L is chosen as the proper compliment of the resistance of the standard meter R_S and the meter under test R_X the AVS-321 output dials will read directly in amperes or milliamps with a reasonable degree of accuracy. The value of R should be chosen as follows:

Full Scale Current	
3 Amps	$R_L = 1 - (R_S + R_S)$
1 amp	$R_L = 10 - (R_S + R_X)$
100 ma	$R_L = 100 - (R_S + R_X)$
10 ma	$R_L = 1000 - (R_S + R_X)$
1 ma	$R_L = 10K - (R_S + R_X)$

If the ammeter being calibrated is a passive meter (i.e. not connected to the power line) the best circuit is as shown in Fig. 9-1

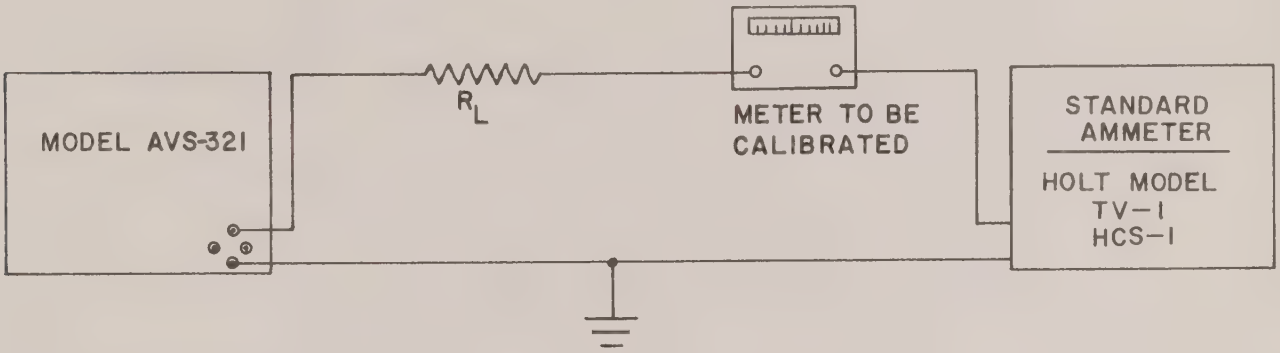

Fig. 9-1

If the meter to be calibrated is connected to the power line the ground point in the loop must be carefully chosen and checked to eliminate current leakage paths. One way to check for leakage current is to insert a fixed resistor in the ground lead and measure the voltage drop across it.

USING AN ISOLATION TRANSFORMER:

An isolating current transformer may be used to obtain two advantages. Using a transformer both the standard ammeter and the unknown ammeter may be grounded. By proper design of the transformer stray capacitive coupling to the supply may be held to very small amounts.

HIGHER CURRENT:

If the isolation transformer has the proper turns ratio considerably higher current levels may be obtained. The maximum current is limited by the 30 watt output capability of the AVS-321 and the impedance of the unknown ammeter. For instance, in using the AVS-321 with a Holt Model TVI (HCS-1) Thermal Transfer Standard to calibrate a meter having a 50 mv 25 amp full scale a nine to one

current transformer will provide full scale current.

The recommended circuit for transformer operation is shown in Fig. 9-2.

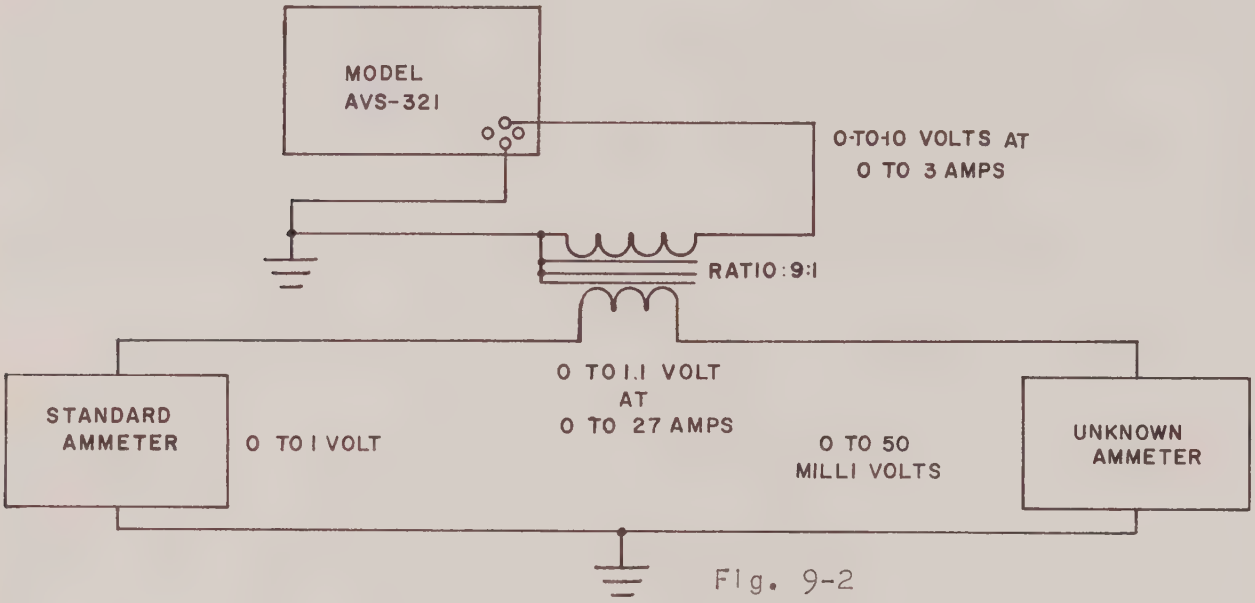

Fig. 9-2

Holt Instrument Laboratories can recommend a current transformer or set of transformers to fit the particular ranges of current, frequency, and burden required.

WATTMETER CALIBRATION: USE AS A POWER SOURCE FOR CALIBRATING WATTMETERS:

The Model AVS-321 has been provided with an auxiliary output terminal connected to the one volt winding of the output transformer. This terminal may be used as a source of current for the calibration of wattmeters by the Phantom load method.

The recommended connection is shown below:

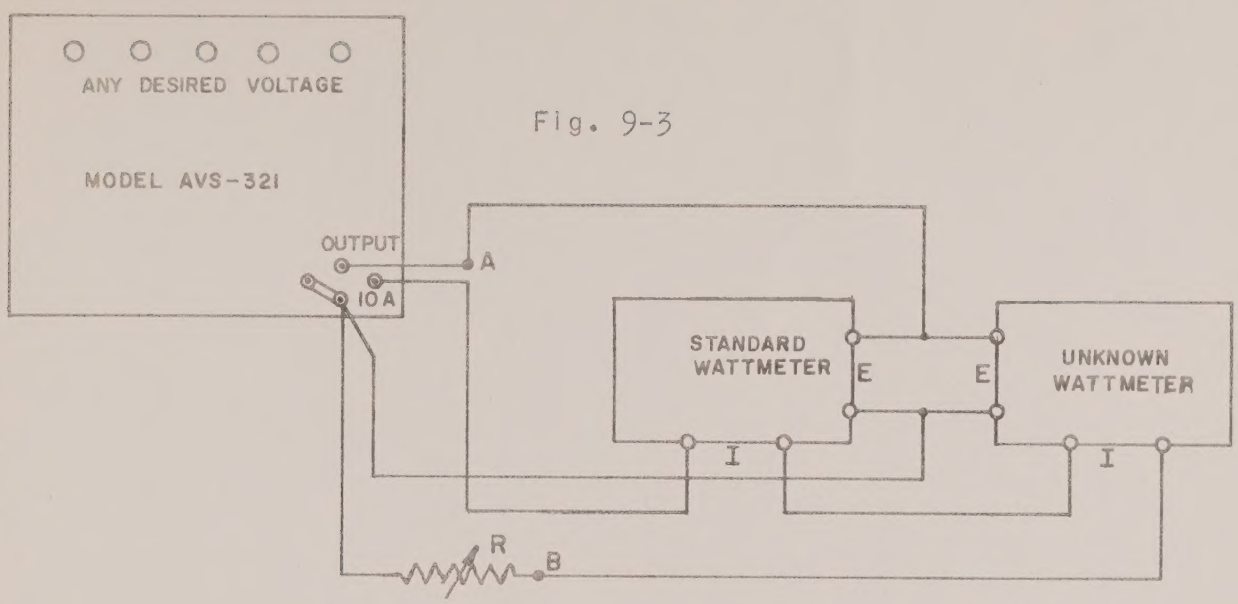

Fig. 9-3

The resistor R is a carbon pile or wire wound rheostat used to set the current in the current coils of the wattmeters. It is sometimes desirable to use a 2 or 3 ohm rheostat in parallel with a rheostat of 100 ohms to obtain better resolution.

The operator may set the AVS-321 to any desired frequency and voltage and adjust the rheostat until the unknown wattmeter is reading a cardinal point. The true power is then read on the standard wattmeter.

At low frequencies the standard wattmeter may be replaced by a standard voltmeter and standard ammeter. Below 400 cycles calibration by this method will be at essentially unity power. The phase angle may be checked by connecting an oscilloscope to point A for vertical deflection and B horizontal deflection.

Wattmeters and watt hour meters with current coils rated up to 10 amps may be checked by this method. Care should be taken to see that the total power drawn from the AVS-321 does not exceed 30 watts.